AN INVESTIGATION INTO THE INFLUENCES UPON AND DETERMINANTS OF PERCEIVED QUALITY ACHIEVEMENT IN THE MANAGEMENT OF CONSTRUCTION PROJECTS BY MULTIVARIATE ANALYSIS

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ABSTRACT

This research concerns a quantitative examination of the influencing factors on the achievement of quality on construction projects. Quality performance on construction projects has been conceived as a function of the design process that occurs before the design of the product, site team collaboration and interpersonal relationships, high work-place-supervision, on-site motivation and role definition. This conception has culminated in postulated determinants of quality achievement on construction based on a theoretical understanding. Aspects of measure of perceived design core job characteristics and site organisation-and-management phenomena were factor analysed. The verification of the postulated determinants was accomplished by testing of a network of eight main hypotheses using multivariate analytical technique in multiple regression.

Varied results emerged with four main hypotheses supported, two partially supported and the remaining two unsupported by data. The assertion is that manipulative actions on design core job characteristics, team collaboration and consensus with mutual understanding and agreement on project goals, mutual exchange with site supervisory staff and subordinates, and role definitions conducted within an integrated framework would contribute an aggregated beneficiary effect on quality achievement on construction projects.

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CHAPTER ONE

INTRODUCTION

1.0 INTRODUCTION

Recently a new cause for concern has been expressed over the standards achieved in building construction. The incidence of major and minor defects in building, particularly housing, has become a common subject being given close attention by the building industry and its clients. Perhaps, the most alarming aspect of building defects in many occasions, is that so many of them are unnecessary. The BRE emphasise this by discriminating between defects and faults where - 'a defect is....a short-fall in performance occurring at any time in the life of the product, element or dwelling in which it occurs' - whereas - 'a fault is a departure from good practice as defined by criteria in Building Regulations, British Standards and Codes, the published recommendations of recognised authoritative bodies, and....for faults of site origin - a departure from design requirements where these were not themselves at fault'. Much rectification work has been treated and funded, as though it were 'maintenance' disguising the fact that what is being 'maintained' is often the product of avoidable faults [36].

It is accepted that 'proper quality' is not always achieved in building construction. Quality in this context means that the item produced is fit for its purpose because it conforms to specification. The item should therefore perform in a specified manner under specified conditions of use for a specified period of time. The most common view of 'lack of quality' in building tends to be related to unfulfilled expectations about their technical performance and durability in use which in turn is considered as either resulting from 'poor design' or 'poor workmanship' - or a combination of both.

As the quest for improving standards in building is intensified, 'quality' is beginning to be introduced to the world of construction in a more extensive way. This is a growing challenge that should be rightly accepted as pertinent and act upon by construction management. A more objective and comprehensive picture of shortcomings and their causes, of the effects of current practices on quality in construction was thought to be needed.

The existence of scant literature on this area of increasing importance is quite evident. Although, there have been studies undertaken in the area, much of the literature from such investigations is oriented towards practice on site and are essentially records of practical observations and reflections of personal opinions and experiences without theoretical perspectives.

It is not the intention here to discuss these studies, but they shall form part of an intended overview of the literature on the subject to be undertaken later in the thesis.

While there has been much work aimed at improving the efficiency of building designers to produce better standards of design, and at developing different techniques of improving construction site effectiveness, there has been relatively little rigorous and programmatic research toward development of theory and verification in the construction management field. Most of the literature has a practical orientation. As such, few guidelines could be derived therefrom. Theory has a very important role to play in scientific investigation. As Kerlinger [175] pointed out....'the ultimate most usable and satisfying relations, are those that are the most generalised, those that are tied to other relations in a theory'....'theories, because they are general, apply to many phenomena and to many people in many places'.

If we are to advance knowledge scientifically in the field of construction management, it is important that efforts should be directed toward the domain of hypotheses formulation and testing that could confirm or disprove the proposition relating to the theory under investigation, as part of research methodology.

The importance of hypotheses in scientific investigation is thereafter pointed out by Kerlinger [175]. He has well stated that "hypotheses are powerful tools for the advancement of knowledge...". Similar view was also expressed by Cohen [84], who stated that - "there is....no genuine progress in scientific insight through the Baconian method of accumulating empirical facts without hypotheses or anticipation of nature. Without some guiding idea we do not know what facts to gather....we cannot determine what is relevant and what is irrelevant" (cf. Kerlinger [175] p.16).

It could be argued that the interpretation of field data without theoretical reflections may not be academically advantageous. As noted earlier, there is little effort directed toward formulation of hypotheses and eventual testing based on some relevant existing theories in construction management field. The foregoing could be understandable in construction, for research into behaviour and other related areas is in its infancy and progressing slowly.

Borcherding [38] has pointed out, behavioural science research in the industrial sector has advanced so far, and there are quite a number of research tools and findings that could be applied to construction situations. He further stated...."as companies grow in size, as projects become more complex, and as additional personnel are needed, difficult human relations problems may arise which threaten the organisation's existence. In attempts to remedy unsatisfactory situations, or deal with unknown behavioural parameters, construction executives and management consultants have drawn from the already existing and extensive library of industrial behavioural research findings".

It is believed here that we could enrich our knowledge in construction management by appropriately applying concepts and empirical findings in the organisational behavioural field.

To summarise, this research is of an applied nature, in which an effort has been made towards developing a theory of understanding the achievement of quality of work on site through construction management. It is hoped that this might help in stimulating further research effort in this area of growing importance.

1.1 STATEMENT OF THE GENERAL PROBLEM

Various sources have indicated that the attainment of acceptable levels of quality in the construction industry has long been a problem. Accordingly, this concern has been expressed for a considerable length of time about the standards of quality attained in construction work and there is a long history of attempts by sanctions or exhortation to improve standards.

Construction is an old complex activity and its particular characteristics as well as its general framework may differ from project to project. When stripped to its basic elements, the industry is one that designs and assembles structures made up of other industries' products, a task which involves formidable problems in organisation. The design process could be thought of as the act of working on and solving a design problem. The assembling or site construction process is essentially to do with physical realisation of the structure based on the information presented in the drawings and specification.

The problem with conventional 'quality control' in the building project process is that it tends to look just at the 'product' and reject it when it does not meet an expected standard. That is, emphasis on 'quality control' is often incorrectly focused on catching mistakes 'after the fact' rather than before or as they occur.

So what are the causes of unsatisfactory construction? Reasons for the poor performance in quality of construction projects by the industry could be identified at all stages of design and construction. The BRE studies [21,36] have come to concerted conclusion that lack of care by people at all levels is playing a dominant part. So that the root cause of the problems may be as much human as it is technical. The technical aspect should be the easier one to tackle partly because the great majority of the deficiencies found on sites studied by the BRE could have been avoided had the designers and site supervisory staff recognised the existence of the problems. The human problems remain and are difficult to embark upon.

One of the problem in the design process pertains to the understanding of motivational properties of core job design characteristics and the influence they have on the achievement of quality in construction. The site organisational setting involves various individuals whose contributions and shared commitments are quite essential for the achievement of intended quality. These contributions and shared commitments are not always realisable.

It is therefore imperative that attention should be focused on ways of improving quality standards in building through more sensitive management and developing methods of assessing management impact on the achievement of high product standards in construction.

It is quite logical that not every factor in the design and site construction processes has equal impact on the achievement of quality in construction. Some relatively exert more influence than others. Hence those factors which have a dominant impact on quality of work in the completed building should be given priority over others. As such, the following research questions can be advanced:

(1) Which design job characteristics influence the achievement of quality in construction?

(2) Which site organisational and behavioural factors influence the achievement of quality at site level?

While this research study attempts to approach such issues, it is here recognised that the quality of the completed building results from shared commitments and contributions of the individuals and parties engaged in the briefing, designing and site construction phases of the building project. However, it was consistently indicated that many problems regarding defective work in building originate with the design and construction phases, consequently, what is of research interest to this investigation is core job design dimensions and site organisation behavioural phenomena to be analysed through the use of selected variables. The following section examines the formulation of the research objectives.

1.2 RESEARCH OBJECTIVES

Quality, or 'the conformance to specified requirements' is something most building designers and contractors would claim to achieve and, indeed, the majority devote considerable effort towards attaining this objective.

Often, however, much of this effort is absorbed in the correction of defects and failures in service.

Coupled with this, because of the complexity of the building process, production groups at the field project level are short lived. They also vary in size according to the complexity of the construction project. This emphasises the need for management in building projects to integrate effectively their objectives both in the design and the field construction phases to ensure the desired quality in the completed building. If the achievement of high quality standards is directly related to the commitment and involvement of people in their jobs, then the quality of employee work performance should be given priority. It would also be of benefit if satisfactory production groups could be transferred wholly from one site to another, thereby preserving their skills and team spirit.

The attention given to operatives, for instance by site management, should be of considerable importance. The recognition of this fact is vital. After all, it is the operatives' work performance that determine the 'quality into the work', and one should unequivocably win their commitment, otherwise no design, specification, contract or control procedure can possibly attain the end required. There is more than sufficient evidence to show that people in the UK have all the skills and ability that are needed.

It is how to manage various forces at work, how to manage people and encourage them to give their best, rather than their mediocrity which must concern construction managers.

While behavioural science research in the industrial sector has reached a high level of sophistication in recent years, and there is abundant data to that effect, the exiguous knowledge we have of how to conform to project requirements are largely fragmentary, experiential and above all, devoid of theoretical orientation. As a result our capacity to understand, assemble the problems and act upon accordingly is very much limited.

The principal concern in this study is to provide building designers and site management with a theoretical framework from which potentially useful indicators could be derived for the understanding and enhancement of quality achievement in building construction.

The major objectives of the research study are therefore summarised hereunder:

1. To diagnose motivational properties of core job design dimensions incorporating selected variables and the influence they have on the achievement of quality of work in construction.

2. To investigate the extent of influence of site organisation behavioural variables incorporating - team collaborative interpersonal relationships, supervisory behaviour, on-site motivational process and role dimension - on the achievement of quality of work on the job site.

3. To reach conclusions, quantitatively, concerning the relative importance of each of the independent variables in determining the achievement of quality of work in construction projects.

1.3 A CONCEPTUAL FRAMEWORK FOR QUALITY ACHIEVEMENT IN BUILDING CONSTRUCTION

Interest in quality assurance within the construction industry is growing, however, it is an issue rarely contemplated in many projects particularly building. Construction projects are becoming more complex, both in what is being constructed and in the number of organisations and pressures having direct influence on the project and its construction. The owner, designer, constructor and one or more governmental agencies all have a direct interest in the projects. Although interest is directed toward many phases of the projects, quality control is of concern to all the principals involved. As the complexity of construction projects increases, the need for a planned systematic approach to quality control becomes apparent for unifying the thinking of all persons involved in the project or its regulation. To that end, a number of approaches have been suggested for the control of quality in construction. Parsons [228], Abdun-Nur [3], Barrie [18], Harding [144], Lawrence [184], Sjoholt [256], Buchanan & Floyd [57], Paepe and Cnudde [226], Cornick et al [89] have intimated that the control of quality in construction, in order to be realistic and practical, and to achieve the level of quality desired, must consider all of the work involved as a total overall activity, not a series of separate facets. A co-ordinating force, viewpoint, a plan to tie the diverse factors together into an integrated whole is needed. This viewpoint leads to the 'systems approach' which has its roots in organisation literature. The systems approach provides a basis for integration by giving us a way to view the total organised activity and for conceptualisation of relationships among internal components or subsystems. Over the past several decades the development of general systems theory has provided a basis for the integration of scientific knowledge across a broad spectrum. A notable writer on the philosophy of systems thinking is Bertalanffy [25,26] who formulated a general system theory. Bertalanffy suggests that the various fields of modern science have had a continual evaluation toward a parallelism of ideas. This parallelism provides an opportunity to formulate and develop principles that hold for systems in general. What made the philosophy of system thinking appealing to this research is the fundamental concept of interdependence and interaction and the concern for the process that occurs before the product. In using the systems approach the object is to focus attention firstly at the level of the whole. Then to identify the sub-parts which interact to make up the whole and the relationships which exist or are necessary for them to interact.

Central to a research is then a conceptual framework serving to direct attention and to structure specific issues under investigation. For the purposes of this research it is not proposed to analyse the complete system of activities and operations which flow from the objectives of the design and production processes but to focus on particular issues which have a major influence on the achievement of quality in construction. For the conceptual purpose of the present research quality achievement in construction could be viewed from the following perspectives:

(i) Technical component
(ii) Psychosocial component

Attributes from each of the above components go a long way in determining the completed building definable as to quality. Each component will be briefly described below:

(i) TECHNICAL COMPONENT

The technical component refers to a narrower spectrum taken to include specification of project requirements, designing and specifying processes, knowledge and skill for the performance of tasks, including the techniques used in the transformation of inputs into outputs. Reference is made here to the building client and building designer who set up the project requirements and design the facility respectively. A key element of this component is the design core job dimensions incorporating a group of variables contributing to the entire set of the research variables.

(ii) PSYCHOSOCIAL COMPONENT

The psychosocial component here refers specifically to site phenomenon comprising individuals and groups in interactions both craft and technical-managerial cohorts. It consists of individual behaviour and motivation, status and role relationships, group dynamics and influence systems. These forces set the entire site organisational climate within which the human participants perform their roles and activities in physical construction and erection of the intended building to stipulated specifications and drawings. In this instance the organisational and managerial actions play a key role in determining the completed building definable as to quality.

For convenience a conceptual framework for quality achievement in construction derived from the foregoing synergestic scheme is depicted in Figure 1.

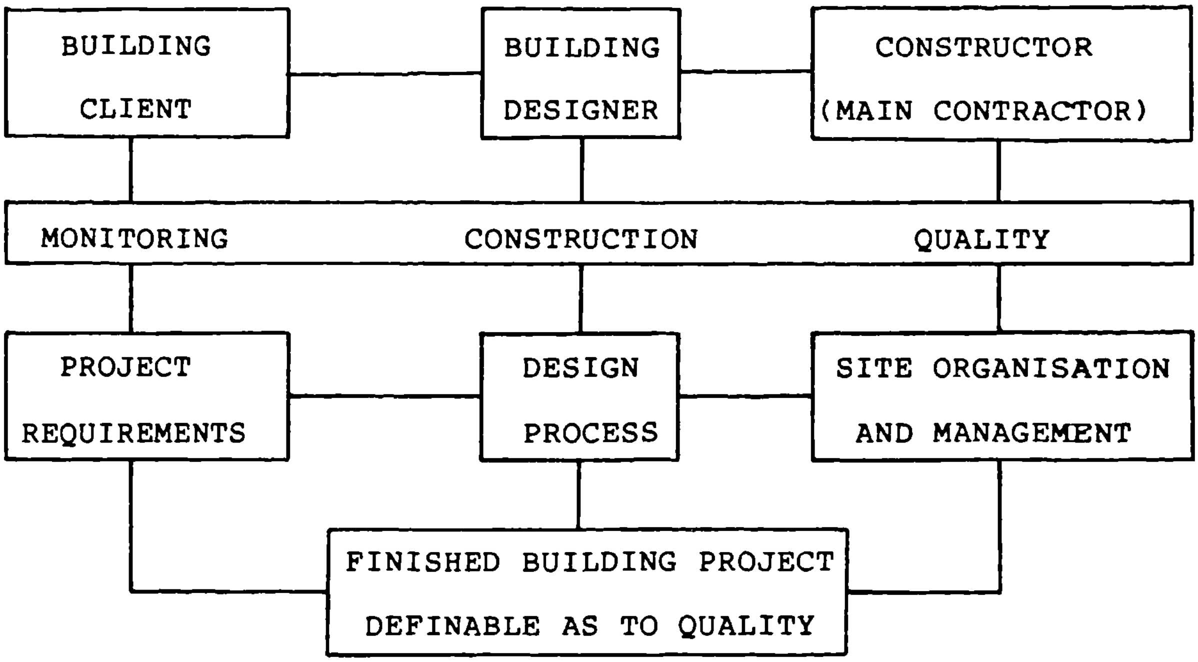


Figure 1: A Conceptual Framework for Quality Achievement in Building Construction

It is emphasised here that the essential element about the framework is that the scheme:

- addresses the processes that result in the product,
- ensures that requirements are clearly defined and their method of conformance agreed and linked through every phase of the process,

- identifies the tasks in each phase in such a way that the common elements of the process in each task can be related in order to ensure that conformance is achieved [89].

This framework will facilitate the selection of research variables and hence sets forth a systematic approach to an empirical investigation of achievement of quality in construction. The selected research variables will be drawn largely from organisation behavioural literature based on theoretical-empirical perspectives.

1.4 PRELUDE TO QUALITY ACHIEVEMENT IN BUILDING CONSTRUCTION

1.4.1 INTRODUCTION

Building projects are realised through processes of briefing, designing, specifying, tendering, constructing and maintaining and responsibilities for these different aspects fall on different people and are dealt with at different points in time. The parties and individuals involved are required to make their own specific types of input. Thus, the quality of the completed building results from 'quality contribution' of the individuals and parties engaged in the building process. Central to quality achievement, then is the enthusiastic participation and support of all the individuals - that is the 'positive commitment' to quality which is fundamental to programmes for total quality control.

It is axiomatic for every kind of building construction process that the following influence product quality. They are: the building client, building designer and building contractor. Based on the conceptual framework discussed earlier, an attempt is made to fit each of the participating parties into the quality equation.

1.4.2 THE CLIENT QUALITY ASSURANCE RESPONSIBILITY

This section of the thesis addresses the achievement of required quality on contracts where the complexity of management and technical functions demand that the client and his representative, together with the contractor, adopt sound quality assurance practices. Attention is focused particularly on the client's responsibilities and the need for planning and communication from the earliest stage.

A successful construction contract is one that is completed on time, within cost and with the required quality and performance. Success is accomplished by technical skill and good management.

A report published by NEDO [219], has highlighted the root causes of faulty construction and emphasised the need to improve the quality of both design and work on site.

Some clients, for instance large housing associations, who need large estate construction projects often belong themselves to large organisations which are characterised by the complexity of their line and functional managements and the levels of authority. If the client is to receive the required quality, he must control his contract in an environment where multiple organisational arrangements exist and where the work and interfaces of the various parties involved must be co-ordinated by appropriate measures. Above all, the client must have effective communication between himself and those to whom he has delegated the various tasks.

A number of major steps were suggested for clients to consider in the management of their projects, to enhance the achievement of the intended quality. CIRIA [79] has identified a number of steps among others relevant to the achievement of the intended quality in the project:

- the client should designate a member of his staff to be responsible within the organisation for the project. The staff member selected should be suitably versed in the procurement of construction. Furthermore, he should have a thorough understanding of the client's business activities relevant to the new construction, and have the confidence of the client's senior management, and be given the authority to act for the client in day-to-day matters relating to the new construction.

- the client should appoint a representative to procure the design, construction and commissioning on his behalf. Some or all of these responsibilities may be allocated to the designated member of the client's staff, should he be suitably qualified to carry them out.

- selecting the contract procedure to be adopted, and determining the extent to which QA will be applied to the project.

Similar views were expressed by Macmillan [199] who noted that, the client must establish a corporate policy whereby his first responsibility is to have enforced within his organisation appropriate arrangements for providing assurance of quality at all stages of the contract. The right people are chosen and guidance be given to those assigned the responsibility for carrying it out.

The second client's responsibility [199] is to correctly specify the requirements for the project. The client may delegate the work to a consultant, architect, engineer or design-and-build contractor, but he will retain overall responsibility for specifying his needs.

The achievement of the specified quality is the responsibility of the contractor chosen by the client and he must demonstrate his ability and those of his suppliers to control the quality of the product. The client must therefore acquire in depth knowledge of the contractor's ability and identify areas of weakness where difficulties may arise. The process of selecting a contractor will require among other things, assessment of his technical performance and the quality of constructed building in earlier similar performance.

The client's other responsibility is to know during construction that quality, as defined within drawings, plans, procedures and instructions, and specification is being achieved and that the quality assurance arrangement being applied by the contractor to ensure compliance with contract requirements are effective.

This could be verified and checked by a knowledgeable representative of the client on site during construction. Therefore the client should appoint an inspector or clerk of works to verify the specified quality is being achieved. It is important that there exists between the client or his consultant and the inspector a clear understanding of the contractor's capability and the implications of the quality specified. This is necessary in order to determine the nature and extent of the verification which is considered necessary that the inspector should undertake.

The remaining responsibility of the client is to provide a forum for the key parties - the client, the designer (architect or engineer), the contractor and the inspector - to resolve any matters which anyone foresees as representing a potential quality problem and to obtain a clear understanding by all parties of the quality assurance activities before contract commenced. An effective way of achieving this is to bring together the key parties - client, designer, inspector, contractor, and if necessary, his sub-contractors at a meeting or series of meetings.

An organised building construction project where the principles of quality assurance were applied was the new Headquarters building of the Hong Kong and

Shanghai Banking Corporation [236]. The client appointed a management contractor who would oversee the construction work and co-ordinate the design activities of the architect and the various consulting engineers.

A requirement for QA does not significantly alter the basic stages of the procurement process but it does affect the way in which they are carried out. In essence, it builds on existing methods but seeks to improve the various procedures [79].

1.4.3 THE NEED FOR EFFECTIVE BRIEFING

The development of a programme for control of quality in construction should include a deliberate selection of objectives and requirements for the building project stated precisely so that they can be understood. The building client should include these requirements, as without a clear and concise definition of requirements, a quality project cannot be designed and built. All materials, components and assemblies age and their initial performance will tend to deteriorate. This must be appreciated by the building client and stating durability requirements - even in approximate performance terms related to specific maintenance programmes - would be a step in the right direction. A lead has already been set in that direction by Property Services Agency (PSA) as a major UK client organisation in the management of quality in the specification of building components [98]. The Agency now stipulates quality assured products and components by firms of assessed capability to National Quality Standards in the specification of their building projects. In the design process for building projects, the Agency derives part of the design brief from a current information database created through effective feedback procedures [98]. It is advocated here that the impetus created and the experience gained by the PSA should motivate other client organisations to follow suit, for instance, the housing associations many of whom are large purchasers of construction projects, in commitment to 'a quest for quality'.

Baggott & Grunberg [15] have indicated that the quality of an initial client brief is not necessarily to be judged by the comprehensiveness of detail, but rather by the clear definition of scope and setting of firm objectives. This initial stage of briefing has been recognised as critical to a building project and the lack of rigorous 'analysis-synthesis-evaluation' cycles - mainly due to pressure of time - has been observed in design practice [197]. Deficiencies in both have been cited as causing quality related problems during construction and in the finished product [219]. Ward [278] has stressed that poor briefs, unstructured client interests and confused project objectives are far too common ingredients in much modern building. Carrington [66] has the view that this part of the building process was simply not considered important enough to merit prior attention relative to other areas of work. Unless the architect has the chance to establish a good working relationship with the client so that philosophies and attitudes can be understood, questioned, evaluated and developed any excellent idea for the proposed project may encounter difficulty in effective translation into action. In a RICS pilot study [135] it was discovered that in a high percentage of cases the clients brief was not sufficiently explicit. In analysing the findings the study concluded that there appeared to be a direct relationship between the quality of the clients brief and the quality of information for the production of tender documents.

As a summary, it is imperative from the above that, attention should be directed to the fact that building clients need to spend 'real time and money' at the inception of the project to identify project requirements and to clearly define in the design the appropriate quality level for the proposed building and its elemental parts. Under the best of circumstances the building client may delegate this responsibility to a competent consultant if he is not capable of undertaking the aforesaid effectively.

1.4.4 THE NATURE OF BUILDING DESIGN WORK

Once the definition of quality is clear, the appropriate mechanisms to assure that a quality project is built can be incorporated into the construction process. The designer's role in this instance is extremely important in this process because too many people quality is 'a measure of conformance' to the established requirements. Therefore, the designer must clearly define what is to be built, how, with what materials, and most importantly, to what specification.

The building designer is working today in a rapidly changing environment involving new regulatory requirements, new technology, materials and products all of which tend to introduce obsolescence to his initial training and technical education. A real problem exists for the designer in being able to appraise successfully all the associated technical information related to these changes and if necessary retrieves the data specific to a given 'TASK'. In as much as there is no quality to control on the job site until the designer sets level of quality needed for the construction of a proposed design, the designer has the responsibility to inform the contractors of the quality level requirements through drawings and specification documents. While it is true that a site organisation would have been provided right at the outset with design information in the form of drawings, specifications and bills of quantities pertinent to the project, it is rare that such sets of documents would be complete, accurate and without discrepancy. "....information is frequently inadequate even in sets of drawings which have been prepared with particular care" [93]. Daltry [97] has highlighted instances of information failure on site. He views conflicting information, errors, non-transmission, insufficient detailing, omissions and poor presentation as potential sources of doubts, confusions and disruptions of site work. Deficiencies in project design documentation are rather commonplace on site. It is precisely the information problem on site which has attracted some research attention culminating in recommendations to improve the co-ordination of design drawings [237]. In examining the reasons for design faults the BRE study [36] discovered that very few of the designers involved had ready access to BSI Codes or Standards. Another was the fact that even the best, most relevant information will not be used unless the designer is aware that he needs it. It has been indicated in a research report by Mackinder and Marvin [197] that there is a tendency by building designers to use written information as design aid less often. Written references are mainly used to check points, or to find solutions to ideas already generated by the designer. The report [197] gives strong indication that designs tend to seek written information as a 'last resort', when their own experience or that available in the office fails to give either an answer to a problem or the understanding to enable a solution to be worked out.

The foregoing clearly indicates the real need for the building designer to 'identify the task' in addressing the process in a given situation, so that both the regulatory and project requirements are fully appraised before the detailed project information is produced. A standard process model for quality control in construction has been proposed [89] to eliminate a number of problems encountered at the design phase. The essential feature of the model is that it is concerned with the process that occurs before the product - whether that 'product' is a 'drawn detail', a 'specification', a 'component', an 'element', or a finished piece of work on site. The BS 5750 design control functions [52] provide a systematic management framework for design and production processes of manufactured products and services. Although it is written with manufacturing in mind, the standard is generic in character and philosophy and therefore universally applicable. The direct application of BS 5750 without adjustment to the design phase of the building project has been advocated [89] and would reduce problems in the subsequent phases. This offers a real possibility of improvement in modern building technology because it addresses the 'processes' that result in the design 'product' which is the key phase that links 'briefing' to 'tendering/construction' and ultimately impacts upon the 'maintenance' (management) phase of the total building project [89]. Therefore, the need to focus attention on the nature of the design job, its assessment and the effects it has on the management of quality in the design process appears warranted.

The theoretical rationale and dimensionality of job characteristics have been provided by Hackman and Lawler [141]. The objective of much research in that direction has been to understand and document the manner in which workers respond to a set of job characteristics (e.g. Brief & Aldag [47], Hackman and Lawler [142], Turner and Lawrence [267]). Turner and Lawrence [267] reviewed the literature and proposed six "requisite task attributes" that they hypothesised would be related to satisfaction and attendance: variety, autonomy, required interaction, optional interaction, knowledge and skill required and responsibility. This measurement instrument, which has stimulated most of the recent scale development work in job design, was originally used in a compensatory, additive model to provide a single summary index that can best be described as 'task complexity'. Sims et al [252] conducted a study that investigated a revised version of the Hackman and Lawler job characteristics instrument with 192 respondants. Factor analyses were conducted on the items from the four core dimensions, plus a dimension describing 'dealing with others' and a dimension on friendship opportunities. An examination of the solution reveals clean definition of all six scales with only a few stray loadings.

In sum, the conceptualisation presented above provides the basis for the part of the present research instruments in understanding 'design core job dimensions' and in their exploration and the achievement of quality in building construction.

1.4.5 SITE CONSTRUCTION PROCESS

In the field of execution the achievement of site construction quality raises many issues as more individuals are involved, and their individual contributions are quite significant to the successful completion of the building project definable as to quality. The site setting is a complex organisation comprising technical as well as human subsystems. It is recognised in much of the current organisation literature that real progress in organisational effectiveness demands our understanding and collocation of both the work and human dimensions within the given environmental context and in integrative framework. Thus attention should unequivocally be paid not only to the work to be carried out but to the participants - in this instance the operatives - who build quality into the work as well. Early emphasis on techniques and procedures in site construction was designed to show when something should be done rather than cognition on requisite guidance and encouragement on what to be accomplished. When quality was observed to 'go out of bounds' it might have been attributed to an assignable cause - inadequacies in materials and components specified, the way they were incorporated into the structure and the level of competence and care in site operations. Emphasis on techniques seems incongruous in view of the fact that one of the most pressing problems is how to influence the behaviour of supervisors and site operatives when quality is not meeting pre-established standards. Adam and Scott [4] have the view that recognition of the problem could lead to attempts to achieve required standards through the use of supervisors and their influence upon the behaviour of their subordinates.

It is of interest at this juncture to note that, the QC circle movement in Japan originated in the engineering community. It was organised to improve quality and other problems faced in the workplace. Its early objectives was clearly that of improving operations, instead of improving attitudes and motivation. The motivational aspect of these systems were discovered after the fact. On the other hand, the quality of work life movement, in the United States, was led by people from the social sciences and human behaviour fields in academia, management and trade unions.

Their objective was to introduce work innovations that would specifically reduce worker dissatisfaction in the work area. They were interested primarily in changing relationships and increasing motivation. The need to integrate these two areas of leadership is now critical and would provide powerful opportunity for achieving the massive quality breakthroughs needed.

The preceding development could provide the bases for site management to create conducive site environment through appropriate leadership whereby satisfactory work would emerge and the operatives were made to understand the standard of quality required and were suitably motivated to do so. The dynamics of systems of collaborative and consensus among the site members including management is an essential feature. As Shepard [250] noted "....in collaboration - consensus systems, leadership refers to the quality of directly confronting differences and working conflicts through to resolution with respect to any issue affecting the achievement of project goals, to the quality of being open to others' attempts to influence, and to the quality of being able to build relations of mutual trust and commitment with all those concerned". As a consequence, in consensus-collaboration systems, good management is understood to be the emergent product of creating teamwork and team spirit and of adequate working relationships among site organisation members. Improving and perfecting communication, control and decision making networks within the site is, first of all, a problem-solving approach to working relations. Here, the site organisation structure under collaboration-consensus is 'task-based'. There is good vertical communication and it tends to be bilateral. Subordinates view supervisors as resources to aid problem-solving rather than as traditional bosses.

Having reviewed the importance of creating conducive site environment, the nature of supervision on building sites reflects certain inescapable characteristics inherent in its function which must as well not be ignored. Atkinson [14], Freeman [126], Harper [146], Clarke [71], Burnell [59], have the view that the key to better 'workmanship' lies in better supervision. And at its most fundamental level, quality at the workplace is concerned explicitly with 'workmanship'. Even though this has been a topic of discussion for quite some time few empirical investigations have been undertaken in this direction. Hatchett [149] remarked that there are conceivably three main areas where supervisory performance is most important;

(a) the first is concerned with the actual processes and tasks to be supervised;

(b) the second is concerned with variety of controls and co-ordinations over these processes and tasks;

(c) the third is concerned with the people who are involved in these processes.

The effectiveness of site supervision is therefore clearly affected greatly by the competence of the individual foreman and site agent and by the appropriateness of their organisation. As Broughton [51] states: "In the last resort, however, the economic development of the project will rely almost entirely on the efficiency of the organisation on the site and the 'quality of the work' will be determined by the effectiveness of the site supervision". Effective site supervision is, therefore, related to a combination of technical, operational and human aspects of construction work.

As indicated earlier, the achievement of site construction quality demands our appreciation of not only the work dimension, but the human factor as well. The significance of human factor on site has largely been directed towards productivity in the form of on-site motivational process in the literature. However, motivation concept in this research is concerned with the attainment of quality in site construction work. Bonshor & Harrison [36], Burt [58], Powell [235], Fletcher et al [125], Abbott [1] and NEDO [219] expressed the view that there is a pressing need to improve the motivation of site operatives toward the achievement of site construction quality. Surprisingly, little research effort has been directed toward this important area of work. The recognition of this fact is vital - after all, it is the operatives who 'build quality into the work', and one must win over their commitment otherwise no design, specification, contract or control procedures can possibly attain the end required. Borcherding et al [40] and Borcherding and Garner [39] have discerned factors affecting motivation. They identified prime motivators as the construction work, sense of accomplishment and supervisory responsibility. The prime demotivators are the lack of support from management, reticent communications, extensive reworking, material and tool non-availability and the lack of recognition for work well done. Laufer and Jenkins [181] have proposed an expectancy motivational theory which comprises three components, i.e. the individual, the job and the work environment. The theory emphasises the importance of considering their inter-relationships for a better insight into the site motivational process. The theory concluded that site motivation is the outcome of a rather complex interplay of the site operatives, their work and the ambient environment.

The concept of satisfaction with the job on site has been examined from productivity perspective (e.g. Borcherding and Oglesby [37]). It was suggested that satisfactions are intrinsic in the construction work per se and that the smoothing of work flow on site appears to enhance job satisfaction. In this research satisfaction is examined in the light of 'supervision satisfaction' that is conceptualised to influence the achievement of quality of work on the job site.

The role played by the Clerk of Works in the achievement of quality of work on the job site has been cited on many occasions. It has been expressed that the Clerk of Works is responsible for and limited to duties of inspection which are not defined, but which must be less than those otherwise associated with his work (e.g. Newlove [221], Black [33], NEDO [219], Bentley [21]). Effective management for quality control should be clearly prescribed, and the delegated Clerk of Works by the client or the architect, should be given both the responsibility and the authority to identify and evaluate quality problems and to initiate, recommend or provide solutions. Unfortunately, in many construction work situations, the Clerk of Works is expected to accept responsibility without formal authority. It is accepted that the Clerk of Works has an important role to play in the achievement of quality on building sites, but there have been surprisingly few direct investigations towards this direction.

In summary, the brief discussion above reviews the complexities and a number of possible factors associated with the achievement of quality of work in construction in the design and construction processes. Attention will now be directed to the selection of variables focusing on specific issues that form the bulk of the research instruments.

1.5 SELECTION OF RESEARCH VARIABLES

The complexity of the building process and the number of influential factors related to the achievement of quality of work in construction call for scope and an in-depth analysis of the interface between the construction processes on the one hand and quality on the other. Due to the constraints on resources facing the author and the complexity of the building process, there is a limitation on the scope, in-depth analysis and variable inclusion for the entire research undertaking. Besides, the current state of knowledge does not facilitate a full specification of influential variables, much less their underlying relationships. The operationalisation process of the variables through the questionnaire will be determined by the length of the questionnaire per se at the data collection phase. In most cases the questionnaire length is a function of the number of variables incorporated which should be kept within reasonable limit as respondents do not like to fill in a questionnaire that takes too much of their time to administer.

The selection of variables will therefore be based on the above limitations and the theoretical and empirical considerations. The selected variables are enumerated as follows:

Independent Variables

A. Design Core Job Characteristics:

1. Required Skill
2. Task Identity
3. Task Significance
4. Job Autonomy
5. Feedback from the Job
6. Dealing with Client and Others
7. Briefing Information

B. Site Organisation and Management:

8. Site Collaborative Interpersonal Relationships

8.1 Problem Solving Through Support and Integration

8.2 Open Authentic Communication

8.3 Knowledge Based Risk Taking

9. Supervisor Initiating Structure

10. Work-Place-Supervision

10.1 Control of work

10.2 Work Facilitation - Goal Setting

10.3 Work Facilitation - Problem Solving

10.4 Work Facilitation - Subordinate Relations

10.5 Participation

11. Internal Work Motivation

12. Supervision Satisfaction

13. Role Strain

14. Role Clarity

Dependent Variable

1. Quality Achievement

1.6 DEVELOPMENT OF RESEARCH HYPOTHESES

The development of the research hypotheses will be partly related to a number of consultations held with the intended participants in the research prior to pre-test data and main data collections.

In most research settings, the choice of component items for an assessment questionnaire is related to the topical coverage in the research instruments suited to the intended assessment and subsequent analysis. One of the identified goals for the choice of the measuring instruments and development effort in the research is to assure that the measuring instrument is suitable for use in a variety of construction project organisational contexts with respondents of diverse situations and characteristics.

Kerlinger [175] has noted that, it is important in any research undertaking to relate questions to the research problem and its objectives; to have the component items clear and unambiguous to the respondents. The questions should not be misleading and should demand knowledge and information that the respondents have.

In a similar view, Anastasi [6] indicated that looking valid to potential respondents is the concern in any measuring instruments and therefore relevance, plausibility and meaningfulness of the scale items are the issue in face validity.

After an initial period of desk research to scan the existing literature, a number of questionnaires were developed and several attempts were made to discuss the intent of the study and the questionnaire contents and its relevance to the practitioners in the field. As a result, an initial set of questionnaires (see Appendix 2) were developed and circulated to the intended participants and to the author's supervisors. This initial set of questionnaires were later discovered to be inappropriate for data collection. A standardised set of questionnaires were therefore selected from scales used in many other research programmes (see Appendix 1) and the set was tested in a pilot study. It was finally discovered that the set was suitable for the research undertaking.

Based on the theoretical, empirical and experiential reflections discussed previously; and the above undertakings, the following hypotheses are formulated to facilitate the research and data collection and verification.

The achievement of high product standards on site is critically and positively influenced by high standards of design, contract documentation, on-site management and operative skills and care. Specifically, the following hypotheses are formulated:

HYPOTHESES

A. BUILDING DESIGN SETTING

A1. The Achievement of Perceived Quality on site is critically and positively influenced by high standards of design, such achievement is influenced by the following variables:-

A1.1 Required Skill

A1.2 Task Identity

A1.3 Task Significance

A1.4 Job Autonomy

A1.5 Feedback from the Job

A1.6 Dealing with Client and Others

A1.7 Briefing Information

B. <u>ON-SITE CONSTRUCTION MANAGEMENT</u>

B1. The Achievement of Perceived Quality on site is critically and positively influenced by team collaborative interpersonal relationship, such achievement is influenced by the following variables:-

B1.1 Problem Solving Through Support and Integration

B1.2 Open Authentic Communication

B1.3 Knowledge-based Risk Taking

B2. The Achievement of Perceived Quality on site is critically and positively influenced by Supervisor Initiating Structure

B3. The Achievement of Perceived Quality on site is critically and positively influenced by Internal Work Motivation

B4. The Achievement of Perceived Quality on site is critically and positively influenced by High Work-Place-Supervision, such achievement is influenced by the following variables:-

B4.1 Control of Work

B4.2 Work Facilitation - Goal Setting

B4.3 Work Facilitation - Problem Solving

B4.4 Work Facilitation - Subordinate Relations

B4.5 Participation

B5. The Achievement of Perceived Quality on site is critically and positively influenced by Supervision Satisfaction

B6. The Achievement of Perceived Quality on site is critically and negatively influenced by Role Strain

B7. The Achievement of Perceived Quality on site is critically and positively influenced by Role Clarity.

Attempts will be made to empirically test the above variables to establish their relative influences upon the (main) hypotheses.

CHAPTER TWO

BASIC CONCEPTS AND DEFINITIONS

2.0 BASIC CONCEPTS AND DEFINITIONS

Below are selected definitions from the literature on Quality Vocabulary. Further explanation or comment relevant to construction has been added.

2.1 THE MEANING OF QUALITY

Speaking about 'quality' in the building industry seems to be rather a difficult matter. Difficult because of the fact that people have different opinions about quality. Difficult because we use different definitions which all prescribe quality in a different way. We speak about product-quality, production-quality, quality of measures, quality of design, quality of workmanship and so on. The need for some operational definition of quality has led to the European Organisation for Quality Control to define quality as [116]:

> "the totality of features and characteristics of a product or service that bear on its ability during its lifetime to satisfy stated or implied needs".

Quality under consideration does not mean goodness, luxury or shininess. It is defined as 'conformance to requirement', therefore, quality means conformance to requirement and non-conformance is the absence of quality [94].

In their mega-model for building projects the Building Quality Trust [60] proposed the meanings of 'quality' in the following hierarchy:

- 'meeting (or conformance to) requirements' is the prime objective,
- 'a level of excellence' must be defined in requirements,
- 'fitness for purpose' is the ultimate result.

Burt [58] defined quality as the totality of the attributes of a building which enable it to satisfy needs, including the way in which individual attributes are related, balanced and integrated in the whole building and its surroundings. These attributes include external - relating to the effects of the site and its surrounding on building, and performance attributes - related to the interior of the building which makes it operationally efficient and provide reasonable conditions for the users.

Atkinson [13] noted that quality is the sum of:

- knowing the customer's needs
- designing to meet them
- faultless construction
- reliable bought-in components and sub-assemblies

- certified performance and safety
- suitable packing
- punctual delivery
- efficient back-up service
- feedback of field experience.

For the purpose of this research 'quality' is defined as 'conformance to requirements' whereby these requirements are clearly defined and communicated to those concerned.

In this research an attempt was made on the measurement of perceived quality achievement by evaluating the current state of the project under construction and relating this to the set out requirements for the project in the drawings and specification. Refer to Section 7.3 of the thesis for more discussion.

2.2 QUALITY CONTROL

BS 4778 [54] defines 'quality control' as - "the operational techniques and activities that are used to fulfill requirements for quality".

In the management of any building project 'quality control' should embrace all the operational techniques and activities in the design and construction of a building project to meet the requirements of a known client. The practice of this activity involves the input of:

- procedures defined by documentation that range from briefing to instructions for site assembly using written 'drawings and specifications',
- people whose motivation for taking part range from the client who has a particular purpose in mind for the building, to the site operative who may solely require financial reward for a particular skill.

Together they partly determine the outcome of a building project.

2.3 QUALITY ASSURANCE

BS 4778 [54] defines 'quality assurance' as: "all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality".

Thus, quality assurance involves the necessary plan and actions to provide confidence through verifications, audits, and the evaluation of quality factors affecting adequacy of the design for intended applications, specifications, production, installation and inspection in a project. It is a systematic way of ensuring that organised activities happen the way they are planned. And it is a management discipline concerned with anticipating problems and with creating the attitudes and controls which prevent problems [236].

Provision of documentary evidence by the supplier could be required by the client showing that specification has been met.

2.4 QUALITY MANAGEMENT

Quality management is defined [52] as - "that aspect of the overall management function that determines and implements the quality policy".

A firm that practices quality management has the expressed and binding commitment of the chief executive and senior management to provide goods and/or services as specified. It follows that quality management permeates the whole of the firm's activities and is not a refinement to which lip-service can be paid solely to appear to comply with a client's wishes.

Quality management is concerned with getting a product or service 'right first time' and implies that the firm carries on its technical and commercial activities in a systematic way, that is, the firm operates a quality system.

2.5 QUALITY SYSTEM

Quality system is defined as [52] - "the organisational structure, responsibilities, procedures, processes and resources for implementing quality management".

Thus, a quality system is the management structure, responsibilities and quality procedures for an organisation which relate to activities affecting the quality of the work carried out. The quality system should only be as comprehensive as is necessary to meet the quality objectives. BS 5750 Part 0 Section 0.2 gives guidance on potential requirements of a quality system.

PART TWO:

OVERVIEW OF THE LITERATURE

CHAPTER THREE

STANDARDS AND QUALITY ASSURANCE SYSTEMS

3.0 STANDARDS AND QUALITY ASSURANCE SYSTEMS

3.1 INTRODUCTION

In this chapter an attempt is made to review the principles and practice of standardisation in building with emphasis on Building Regulations, Codes, British Standards, Certification and quality schemes.

Nagarajan [213] defines standardisation "as the process of formulating and applying rules for an orderly approach to a specific activity for the benefit and with the co-operation of all concerned and in particular for the promotion of optimum overall economy taking due account of functional conditions and safety requirements".

Cooneley & Agnew [88] and Verman [268] expressed similar definition. They pointed out that standardisation determines the basis not only for the present but also for future development, and it should keep pace with progress.

Standards in building are probably as old as man. The most outstanding building constructions through the ages, which remain even today, include the Khufu Pyramid in Egypt, built around 4700 BC during the reign of Cheops; the Anio Novas aqueduct in Italy, 89 km long, built by the Roman Emperor Caligula during AD 36-86, carrying a waterway 2.4m high and 0.9m wide, with a maximum height of arch or about

30m; the Great Wall of China, 2240 km long and 65m high, going over mountains and valleys, with facings of brick and granite filled with earth; with a 4m wide roadway at the top and towers at about 100m spacing, built during the reign of Chin Shi Huang Ti, and the Taj Mahal in India, considered to be a jewel among monumental buildings, built between AD 1632 and 1650 during the reign of Shah Jehan by the architect Ustad Isa [270].

The nature and complexity of these buildings and structures leaves one in no doubt that a high degree of planning and standardisation in relation to building existed all through the ages [269].

The application of standardisation in building could be considered in relation to the design of the building, and to the products and processes, e.g. definition and selection of characteristics of products, testing and measuring methods, specification of characteristics for defining "quality", building regulations and codes, etc. for safety of persons and property. The relationship between standardisation and systems of proportion in architectural design was expounded in the writings of Vitruvius [270], Roman architect and engineer, round about 27 BC. Among his doctrines the most important is possibly his insistence on important buildings and temples being provided with a certain measure of symmetry and proportion based on those of a well-shaped human body. He also desired that, in the members of such buildings, there ought to be the greatest harmony in the symmetrical relations of the different parts of the general magnitude of the whole. Karzyk [174] has attempted to throw some light on the standardisation of buildings during the Romanic period and in biblical times. He stated that the biblical units of length in buildings were based upon the size of the hand but never the foot. There have been many engineers and architects, starting from the earlier times, who have attempted to relate the symmetry and proportions of the building to those of the human body. The relatively recent contribution of Le Corbusier [185], one of the talented architects of all time, should be considered as one of the most rational and scientific contributions on this subject. He explained this relationship through his modular, which is based not only on the human body but also on mathematics.

Although important buildings and temples have been constructed with special references to aesthetics it does not appear that equal importance was attached to structural and functional considerations. It is only recently that exhaustive scientific studies have been undertaken on the engineering properties of materials and the development of new building materials and also on the functional requirements of building, especially for housing [268]. It is on the basis of these studies that attempts have been made to evolve rational performance standards [281].

Throughout the long history of standards in buildings in the ancient and early industrial phases we find repeated references to attempts at the standardisation of bricks. Weston [285] wrote about the development of English Building Construction, and said: "In the year 1477 the mode for making bricks for building was 9 in. long and 4.5 in. broad, and the bricks when burnt, were to be 8.5 in. long, 4 in. broad and 2.5 in. high. They were further regulated by Acts of Parliament in 1567-68 and 1625".

Throughout the ancient and early industrial phases, standards in building, building regulations, and codes as we know them today did not have separate identities and were one and the same. Building Regulations and Codes which included various technical provisions, and which find separate existence today in standards in building, were enforced by the State authorities, mainly to ensure reasonable standards of health and safety to the users. The term "code" in the field of standardisation in building is defined [213] as: "A document setting forth requirements based on certain considerations, frequently health and safety, and the criteria and standards against which compliance with the requirements is measured. It is usually intended for impartial regulation of an area of activity. The most important codes are those promulgated by government, thereby acquiring the force of law".

3.2 STANDARDISATION IN THE MODERN INDUSTRIAL PHASE

The modern industrial phase in standardisation is said to have started in the United States at the close of the 18th Century with Eli Whitney, the inventor of the cotton gin and a manufacturer of firearms [213]. To Whitney, who was given an order for about 10,000 firearms, is attributed the original idea of interchangeable parts, divisions of labour and mass production in the modern sense. These concepts ultimately led to the idea of specifying precision by tolerances in manufacture and quality control, and the development of suitable tools and machinery for different manufacturing operations [269].

Although the developments mentioned above do not have a direct reference to standards in building, it is seen that these and other developments of new building materials and their manufacture under factory conditions conforming to predetermined quality standards for the first time. There is extensive documentation on quality control in the manufacturing of various construction materials. Other articles deal with segments of comprehensive quality control programmes such as the monitoring function to meet some standards [154]. General trends in the evolution of quality control are much more extensively documented for the manufacturing industry than for the construction.

Iron and steel products and cement were manufactured under factory conditions and were made available for use in building during the modern industrial period. Architects and engineers began specifying diverse types of steel section, as a result of which manufacturers and dealers recognised for the first time the need for evolving and standardising suitable steel sections for ease in manufacture and later stock control. The need for evolving such sections formed the subject of considerable correspondence in the Times in 1895, and attracted considerable public attention [269]. In fact, this particular item became the first exercise in organised industrial standardisation activity in Britain [213].

3.3 ORGANISATIONAL PHASE OF STANDARDISATION

British Standard Institution (BSI) is the first national standards body in the world, formed in 1901, which later became a model for many other national standardisation bodies. The BSI first began as a committee appointed by the council of the Institute of Civil Engineers London, to consider the advisability of standardising various kinds of iron and steel sections, mainly for use in buildings and structures. For discussion on the recent activities of BSI read Section 3.5.

In the same year, 1901, the National Bureau of Standards was formed in the United States of America, and later the American Standards Association was formed in 1918.

The establishment of national standards bodies in many other countries followed these developments, and in 1926 twenty countries met to form the International Federation of National Standardising Association (ISA), which became effective in 1942. In the year 1947 International Organisation for Standardisation (ISO) was officially formed and replaced ISA, as a result of a meeting held in London by the United Nations Standards Co-ordinating Committee (UNSCC), and other national standards bodies of allied countries [269]. One of the main objectives for the formation of ISO was to promote the development of worldwide standards, with a view to facilitating international exchange of goods and services, and of development co-operation in the sphere of intellectual scientific and economic activity. The ISO has been directly and indirectly responsible for the awakening of interest in standardisation throughout the world and today has a membership of over 50 countries.

The establishment of national and State building institutes in most countries encouraged a considerable amount of research work, which contributed to the formation of standards in buildings. In the year 1953, the

International Council of Building Research Studies and Documentation (CIB) was formed to co-ordinate building research and documentation work throughout the world.

One of the main objectives of the CIB is to promote standards in building based on the results of scientific research. The CIB is conscious of the fact that the most efficient way of utilising building research is through standards in building and building regulations and codes.

With the establishment of national standards bodies the task of formulating standards rests with these bodies for government agencies [213]. Model building regulations and codes are formulated by National Standards bodies or professional societies, and these are made use of by government agencies in formulating building regulations and codes for different towns and areas. Building regulations and codes always incorporate standards in building.

3.4 ROLE OF STANDARDS IN QUALITY ASSURANCE

All forms of control require the establishment of standards, whether at company, national or international level. These standards should cover the determination of a product or service requirements in a way which encourages rather than inhibits construction or performance: means of comparison and assessment of quality, reliability, safety, and value for money, and the application of suitable corrective action when necessary. Figure 2 shows the fundamental role of standards and specifications in the determination and measurement of quality.

In particular they provide a basis for management systems of project control, including the allocation of resources and agreement of price and delivery requirements with clients. Standardisation and quality assurance are thus two basic functions of management which interact at several levels within organisations, irrespective of the type of product or service provided.

There are three principal types of standards [118]:-

1. Physical standards used for mass, length and time, relate to physical quantities or are defined in terms of a natural phenomenon. Standard reference materials (SRMs) are another important form of this type of standard. They are particularly important in the calibration and metrology aspects of quality assurance, for example the principle of traceability functions of the National Physical Laboratory and the British Calibration Service in the UK.

2. Conceptual standards encompass customs and traditions where the standard is neither in the form of a physical object, nor a formal document, but is passed on by word of mouth from generation to generation (as

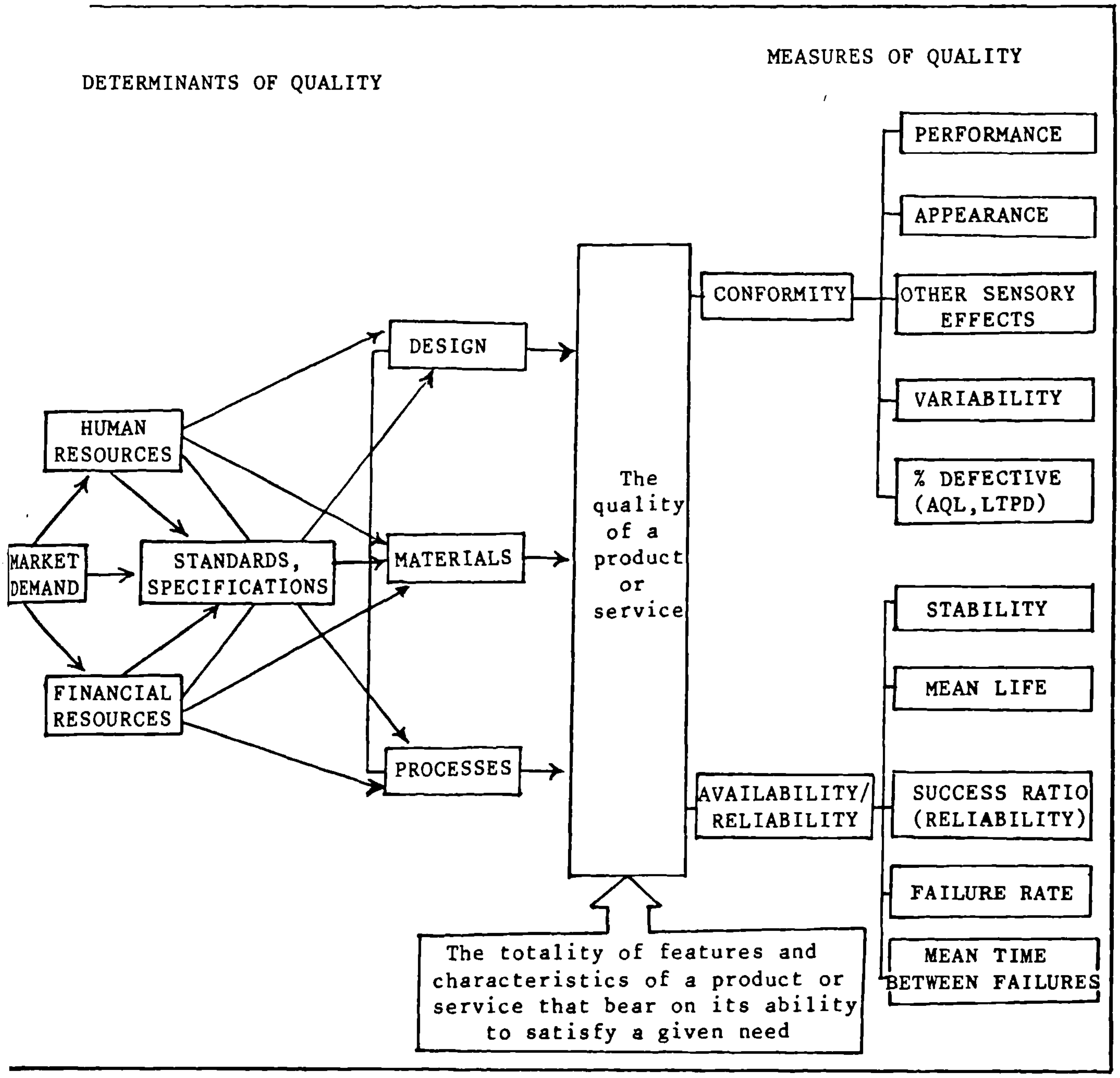


Figure 2: Some of the Principal Determinants and Measures of Quality
Source: BSI Handbook 22.

noted earlier in this section). Examples are behavioural norms and intrinsic levels of skill possessed by craftsmen. Standard reference data (SRD) may be considered as another form of conceptual standard: although they are precisely determined and carefully documented, they remain conceptual in nature.

3. Documentary standards, which by far are the most common form, are either mandatory standards, i.e. government statutory regulations and requirements, or voluntary (consensus) standards which may be given the force of law if invoked by contract.

Particular attention will be paid to documentary standards in the rest of this chapter.

The scope and range of documentary standards is shown diagrammatically by the Verman Standardisation Space Concept [269] in Figure 3.

This diagram differentiates standards in terms of level, e.g. national, international, company, associations; field, e.g. engineering, construction, food, textiles, etc.; subject, e.g. glossary, guide, code, method of test, specification.

3.4.1 INFLUENCE OF BUILDING REGULATION AND CODES

From time immemorial, the regulation of building activity has been one of building regulations and codes. Building regulations and standards in building became separated only in the present century, due to the latter being formulated by national bodies, set up in this period [213]. The technical contents of building regulations and codes which are implemented by government agencies are largely dependent upon standards in building. Standards in building and building regulations and codes are complimentary, together assisting in the scientific regulation of building activity.

Regulation of the design and construction of buildings by authorities has a long history. Regulating authorities have different aims, not always achieved or sometimes achievable [13]. Almost always the regulations have had an effect on the quality of the resulting works though only occasionally has the achievement of quality been specifically mentioned in the legal documents.

The Building Act 1984 is a recent example. It gives the Government power to make building regulations for any of the purposes of:-

(a) securing the health, safety, welfare and convenience of persons in and about buildings and of others who may be affected by buildings or matters concerned with buildings.

(b) furthering the conservation of fuel and power, and

(c) preventing waste, undue consumption, misuse or contamination of water.

Though no mention of quality was made, its provisions through frequent reference to British Standards and a still somewhat cautious reference to quality assurance, will, as its predecessors did, have a strong influence on quality of construction.

An early objective of regulation was to prevent spread of fire. The 1667 Rebuilding Act, after the Great Fire of London, had this as a central aim. But matters relating to quality were soon introduced in the London Building Acts [13]. For example, there were requirements for different sorts of building to the end that builders may the better know to provide and fit their materials. 'Fitness for purpose' was to be achieved by specifying different wall thicknesses for buildings of different heights, maximum lengths for the bearing of joints and single rafters and their spacing.

3.4.1.1 Materials

Central to the development of quality in construction is the influence of building regulations, and particularly of the guidance given in the DoE Approved Document to Support Regulation 7 [13].

The requirement to which it refers states: 'Any building work shall be carried out with proper materials and in a "workmanlike manner"'. If reflects Part B1 in the Building Regulations 1976 which requires that:

'Any material used.........shall be

(i) of a suitable nature and quality in relation to the purposes for and conditions in which they are used;

(ii) adequately mixed or prepared, and

(iii) applied, used or fixed so as adequately to perform the function for which they are designed.'

The 1976 Regulation [13], had a second clause which states that these requirements apply 'only so far as they are necessary for ensuring public health and safety'.

It is worthy to note that in the new DoE Approved Document [13] the sort of evidence that can be used to establish the fitness of materials is spelled out by reference to:

(a) Past experience - the material can be shown by experience, such as in a building in use, to be capable of performing the function for which it is intended.

(b) Agrement Certificate - the material is covered by an Agrement Certificate and the conditions of use are in accordance with the terms of the certificate.

(c) British Standards - the material conforms with a British Standard which is appropriate to the purpose for and the conditions in which the material is to be used.

(d) Independent Certification Schemes - one of the more widely used product certification scheme is the Kitemark scheme operated by the British

Standards Institution. Any material which is Kitemarked can be taken to conform with the relevant British Standard and to meet the requirements of the Building Regulations. Materials which are not Kitemarked may still conform with the relevant British Standard.

(e) Quality Assurance Schemes - the material is covered by a scheme which complies with the relevant recommendation B.S. 5750 quality systems such as one of the schemes of Registration of Firms of Assessed Capability operated by the British Standards Institution. BSI schemes relate to specific groups of products or processes for which there may or may not be a British Standard.

(f) Tests and calculations - it can be shown by tests, calculations or other means, that the material is capable of performing the function for which it is intended. The NATLAS Accreditation Scheme for Testing Laboratories offers a way of ensuring that tests are conducted in accordance with recognised criteria.

(g) Sampling - local authorities have the power to take samples of materials used in building work. Regulation 16 allows them to take and test such samples as they consider necessary to establish the provisions of Schedule 1 (List of requirements).

3.4.1.2 B.S. Codes of Practice for Workmanship

A similar list of 'aids for establishing the adequacy of workmanship' is given with appropriate wording such as references to British Standard Codes of Practice.

Some years ago it was common for the site agent/manager to have several of the most common B.S. codes of practice on a shelf in his site office. As the tempo of change in the building industry quickened, so did the frequency of issue of new and revised standards, while the cost of British Standard publications increased at a greater rate than inflation [109]. As a result, it is rare to see copies of British Standards and Codes of Practice on building sites today, even though it is specification requirements.

As most contractors only need the information relevant to site storage, handling and installation, the BSI decided to develop codes of practice for workmanship on building sites covering the basic requirements of common construction operations. The drafts recently published for public comment cover 19 aspects of construction:

(1) excavation and filling, (2) concrete work, (3) masonry, (4) substructure damp-proofing, (5) carpentry, (6) joinery and general fixing, (7) slating and tiling, (8) flat roofing, (9) glazing, (10) plasterboard partitions and dry lining, (11) cement sand screeds and concrete toppings, (12) plastering and rendering, (13) wall tiling, (14) floor tiling, (15) painting and decorating, (16) decorative papers and fabric wall cover, (17) above ground drainage and sanitary appliances, (18) below ground drainage, (19) hot and cold water services.

Format

Each part of this B.S. draft is organised along similar lines with sections on:-

(1) delivery, handling, and site storage of materials and components
(2) preparation work and preparation of materials and components on site

(3) erection, fixing, installing, laying or applying the work at the work position

(4) inspection and testing

The sequence of the clauses is thus related to the sequence of operations on site.

<u>Aims of the Code</u>

The following indicate briefly the aims of the code:

(1) To provide a standard which can be involved in building contracts as the source of descriptions of basic workmanship.

(2) To improve communication and understanding within the industry on the basis of one document common to many contracts.

(3) To provide requirements for use on building sites as an aid to controlling the quality of workmanship and to assist in the judgement and settlement of disputes.

(4) To provide a reference document for operatives, site supervisors and specifiers.

3.5 BRITISH STANDARDS INSTITUTION (BSI)

British Standards are technical documents produced as national standards to satisfy defined requirements at the request of particular industries and organisations. CIRIA report [236] defines "British Standards as a document published by the BSI which details requirements that a product, procedure, services or material must meet to be fit for a certain purpose".

The BSI is a National Standards body which began in 1901 as the Engineering Standard Committee, its national importance being confirmed when it received a Royal Charter in 1929. The Charter gave BSI two main responsibilities:

(a) To co-ordinate the efforts of producers and users for the improvement, standardisation and simplification of engineering and industrial materials, so as to simplify production and distribution, and to eliminate the national waste of time and material involved in the production of an unnecessary variety of patterns and prices of articles for one and the same purpose.

(b) To set up standards of quality and dimensions, and prepare and promote the general adoption of British Standards specifications and schedules in connection therewith.

3.5.1 BSI'S CONTRIBUTION TO QUALITY IN CONSTRUCTION

The BSI is one of the largest providers of services in the field of quality assurance. The Quality Assurance

Council of BSI came into being in 1971 and the services are operated by the QA Division situated at BSI centres at Hemel Hemstead and Milton Keynes. The Division consists of three departments [95]:-

1. Certification and Assessment - this deals with all the BSI Certification operations including the Kitemark System and the Registered Firms Scheme, and the B.S. 9000 System (electrical components). There are now 93 Kitemark Schemes operating for construction materials and components, each designed to provide independent assurance of conforming with a specific British Standard. This department also provides technical and administration services to other certifying organisations. Recently the BSI started a scheme of Registered Firms (including construction organisations) under the BSI Quality Assurance Services (BSI/QAS).

2. Test House - this is one of the largest independent testing organisations of its kind in Europe, serving both private and public sectors of industry. Tests are commissioned against national and international Standards, trade associations and company specifications.

3. Inspectorate - this provides a range of assessment and surveillance services of manufacturers' products and internal quality assurance schemes.

The main vehicle for communication with BSI members and more generally with industry is the monthly BSI News, which gives information about standards work, as well as certification news and about BSI's testing services. BSI News is the main vehicle for keeping up to date lists of British Standards, amendments to B.S.'s, work started on new B.S.'s, etc. and as amendments to the yearly Buyers' Guide, changes to the lists of Kitemark and Safety Mark licensees, and Registered Firms.

3.5.1.1 Kitemark Certification

The 'Kitemark' registered trademark may only be used by manufacturers licensed by BSI under a particular Kitemark scheme. Kitemark status for a product indicates that samples of that product have been examined and tested by BSi for compliance with the construction, performance, safety or dimensional parameters called up in the relevant British Standards. It also indicates that the manufacturer has agreed to a system of factory surveillance visits by BSI inspectors. The Kitemark Certification Scheme has been in existence for some 75 years and there are currently in excess of 200 Kitemarks involving some 1,500 Kitemark licenses.

It is notable that this particular system's main outlet is the building and construction industries. An example of a corporate client that uses the Kitemark products is the Property Services Agency (PSA) which calls up more than 70 Kitemark Schemes. Kitemark systems have a built-in recall procedure, where all customer complaints are investigated in order to maintain the integrity of the system.

3.5.1.2 Safety Mark Certification

The 'Safety Mark' appears on products which conform to British Standards specifically concerned with safety. It is a certification system that is mainly used in the electrical and gas industries and has an obvious application to the construction industry.

In 1976 the Q/45 Committee was formed to introduce quality assurance criteria for 'Building and Construction Materials and Components' [95]. The early problems facing the Committee were concerned with obtaining a consensus of agreement that there was in fact a need for quality assurance of materials in such a complex and fragmented industry. In addition, there was the need to have regard for a compatibility of interest with those schemes already initiated by associated industries, e.g. TRADA and NHBC. However, it gradually became evident that any reduction in the wastage of rejected components (especially after delivery to sites) could yield economies and enhance a firm's reputation for quality products.

3.5.2 PUBLISHED STANDARDS ON QUALITY ASSURANCE

National Standards, as noted earlier, are produced to satisfy defined requirements at the request of particular industries and organisations. BSI is one of the largest providers of services in the field of quality assurance, and there are publications produced by BSI to this regard. Recently the BSI published a handbook [49] containing seven published standards (fifteen publications) on quality assurance. All the standards in the handbook have universal application and although written mainly in the context of the manufacturing engineering industries, they are equally applicable to the process, construction and service industries and to chemical, pharmaceutical and textile industries, etc. with a minimum of adaptation.

The seven standards are grouped under three headings [49]:-

1. "Terminology standards" which set down agreed terms and definitions in current quality assurance practice:-

B.S. 4778 - 'Glossary of terms used in quality assurance (including reliability and maintainability terms)'

B.S. 5233 - 'Glossary of terms used in metrology'

2. "Basic or generic standards" which are written in the form of guides (not involving contractual requirements):-

B.S. 4891 - 'A guide to quality assurance'

B.S. 5760 - 'Guide to the reliability of systems, equipments and components' (in two parts plus DD16)

B.S. 6143 - 'Guide to the determination and use of quality related costs'

3. Definitive system specifications (with guides) for use in contractual situations:-

B.S. 5750 - 'Quality systems' (in 6 parts)

B.S. 5781 - 'Measurement and calibration systems' (in two parts)

It is worthwhile to discuss the contents of these seven standards and comment on those most suitable for application to construction.

The B.S. 4778 and B.S. 5233 define terms used directly in the other five standards. For ease of reference they are divided into sections by function, e.g. general terms, certification, reliability, maintenance, and by usage, e.g. management, design, manufacture, inspection, measurement [49].

B.S. 4891 is a basic (source) document dealing broadly with the whole field of quality assurance. Its fourteen contents headings form the basic structure of the other standards. This standard underlines the vital role of top management in establishing a defined quality policy in terms of objectives, programmes and personnel responsibility. It then proceeds to discuss the requirements and controls in various departments, e.g. marketing, purchasing, design, manufacturing, distribution, and servicing, and finally deals with specific quality assurance procedures such as inspection/quality control, instrumentation and measurement sampling, documentation, auditing and review and all the all-important analysis and control of non-conforming items.

The B.S. 5760 is currently being developed as a three part standard, Part 1 indicates that today reliability can no longer be considered in purely qualitative terms as defined in Codes of Practice, but requires to be expressed quantitatively. It shows how this can be managed and goes on to discuss the essential features of a comprehensive reliability programme. Part 2 presents the detailed mathematics for the assessment and prediction of the quantitative and statistical aspect of reliability. Part 3 gives examples of reliability practices.

B.S. 6143 gives advice on how to identify and control quality related costs in a manufacturing organisation. It considers costs under four headings:

1) prevention costs,
2) appraisal costs,
3) internal failure costs,
4) external failure costs.

It outlines the gathering, analysis and tabulation of quality costs and how these costs are related to existing cost and production data and ends with some procedural recommendations.

B.S. 5750 is a three level specification of definitive quality assurance requirements for manufacture of products and/or services under contract conditions. Part 1 is applied when the technical requirements and performance of products and/or services are specified in general terms and where designs and data have not been pre-established. Part 2 is applied when the technical requirements and performance are specified in terms of established designs and data where conformance is ensured mainly by inspection and test during manufacture and if necessary during installation. Part 3 is applied when conformance to specified requirements can be adequately established by inspection and test of the finished product or service.

As B.S. 5750 is the UK national standard for quality systems, and now an international standard, ISO 9000, an attempt is made to discuss further on it and comment on its application and limitations to the construction industry.

3.5.2.1 B.S. 5750: The UK National Standard for Quality System

Quality assurance, as defined earlier, is the organisation and assessment of those activities and functions which are concerned with attainment of quality.

B.S. 5750/ISO 9000 [52] the UK national/international standard for quality provides complete control of quality from planning the design, through procurement and production, into commissioning and operation. It is claimed to be a practical standard for use throughout industry. Its principles can be applied whether the organisation is small or very large [52]. It sets out to specify how a firm can establish, document and maintain an effective and economic quality system.

Before examining the applicability to construction, it is useful to look a little further at the explanations given in An Executive's Guide to the use of the UK National Standard for Quality Systems [55] which BSI prepared as a contribution to the National Quality Campaign. The Guide listed and answered eighteen questions:

1. Who should be responsible for functions affecting quality?

   Ans: The advice is that the job of co-ordination and monitoring must be in the hands of one man, possibly with the purchaser having his man to look after his interests - could this apply to clerk of works/resident engineer or architect?

2. How should the quality system be kept effective?

Ans: By periodic checks and systematic reviews.

3. What are the planning considerations involved?

Ans: The quality system must take into account other functions like design, manufacturing, sub-contracting and installation, and particularly unusual contract requirements.

4. What documented work instructions will be required?

Ans: Customer's specified requirements should be put on paper in simple form for operatives.

5. What records will be required?

Ans: Records are the objective evidence of meeting the customer's requirements, they need an efficient storage and retrieval system.

6. How can defects be found and corrected?

Ans: By prompt and effective corrective action, action which must extend to products and services provided by sub-contractors.

7. What design functions should be controlled?

Ans: This is the lengthiest section. As it is of special interest for construction activities, the answers and the further guidance given in Part 4 of B.S. 5750 are discussed under a separate heading in the next section.

8. What sort of system is needed for control of documentation and subsequent changes?

Ans: A section of relevance to construction, particularly as much attention has been given to the development of co-ordinated systems for documentation like sfB, yet the industry as a whole has a long way to go to reach agreement on how to co-ordinate and communicate.

9. What control of inspection, measuring and test equipment is required?

Ans: The Guide notes: 'The measurement and calibration system should be in line with B.S. 5781, Part 1'.

10. What about the control of purchased material and services?

Ans: Because of the nature of construction contracts, material coming on sites is more likely to be checked against delivery for costing than control of quality.

11. What controls are needed in manufacturing operations?

Ans: In terms of operations on many building sites, the following advice in the BSI Guide could raise a hollow laugh: 'On the factory floor disciplined control is essential. In any operation or process is excluded or missed out from your control procedures, the result may be below standard products' - yet it is very true on construction sites as on a factory floor.

12. What happens if material is supplied by the purchaser?

Ans: You must assure yourself that it is suitable for its purpose.

13. What is required at final inspection and test?

Ans: Another requirement which, superficially at least, appears to restrict the application of B.S. 5750 principles to manufacturing; yet there is surely an equal need for effective and efficient procedures to be developed at the inspection stage before issue, for example, of a certificate of practical completion.

14. What sampling procedures would be used?

Ans: At least in concrete work, the construction industry has made advances in recent years.

15. What controls are needed for non-conforming materials?

Ans: Again largely an answer written in a manufacturing context, but disposal of 'condemned' materials is also a problem on construction sites.

16. What about the inspection status of material in the production process?

Ans: Written control procedures are necessary to enable you to establish quickly at all times whether material has:

Not been inspected

Been inspected and approved

Been inspected and rejected

17. What procedures are required to protect and preserve product quality?

Ans: The comment - 'the handling and storage of materials, components and the finished items are important parts of the quality system' is equally relevant to construction where, for example, BRE surveys show how wasteful and damaging the handling and storage of materials and components can be on many building sites.

18. Is there a need for training?

Ans: Clearly, it is important that your staff and workforce are properly trained to carry out the operation of your company in the way that you and your quality system require.

The above eighteen questions and answers demonstrate the origins of B.S. 5750 in manufacturing and some of the resulting difficulties in applying to principles to construction and at the same time, how much of its guidance is relevant.

In the author's opinion the most relevant part of the system is the section dealing with design control, which will be highlighted in the following sub-section.

3.5.2.1.1 B.S. 5750 'Design controls'

When it is accepted that the fundamental processes of design and production apply equally to the making of buildings as to any manufactured product; one of the most relevant sections of the standard is the 11 design control functions.

These control functions also suggested in the standard would become a basic requirement of any design practice wishing to have their own management processes accredited against these 'quality' standards.

The outline requirements of these design control functions specified in Part 1, and expanded on in Part 4 of the standard, are as follows:-

1. The provision where necessary of a design and development programme.
2. The provision of a code of design practice and procedures.
3. The investigation of new techniques.
4. The identification and control of design interfaces.
5. The preparation and maintenance of drawings, specifications, procedures and instructions.
6. The control of physical and functional tolerances to avoid irrational limits.
7. The consideration of statutory requirements.
8. Environmental evaluation of new materials.
9. Control of the reliability and value engineering tasks.

10. The establishment of design review procedures to ensure progress towards the achievement of the design and development of problem areas.

11. The use of defect data feedback from previous designs, where appropriate.

All these functions are as applicable in the 'building' design process as they are in the 'manufactured product' design process and it is difficult to see how they need to be either increased, reduced or even amplified [89]. Some of the 11 design control functions merit short comments as follows.

- The second point is quite relevant to construction, as the need for such a code is even greater where, as is usual in construction, design work is divided between many practitioners. B.S. 5750: Part 4 states:-

> Design responsibilities and interfaces should be defined at a level appropriate to the design task.. where complex requirements are involved and/or the (supplier's) design organisation is a large multi-product, multi-discipline one, responsibilities and interfaces should be defined in detail.

Design documentation should consist of drawings specifications (normally referenced through a formal numbering system), instructions, and other relevant output documents, e.g. log books, calculations, sketches, analyses and test results, which indicate the design concept and assumptions.

- The investigation of new techniques is worthwhile as in point three, but it is often difficult to strike a balance between innovation and standardisation. Adherence by designers to a set of proven components and techniques is desirable in the interests of reliability, maintainability, and variety reduction. On the other hand, inhibiting designers from using recently developed components and techniques can limit the performance of the design and lead to technical stagnation [13].

- Point four is quite relevant, though written in terms of manufacturing industry, this requirement becomes even more important in construction where much of the design is undertaken by specialist consultants and sub-contractors.

- Again point five is important to construction. Procedures should be prescribed for the identification and revision status of design documents, records of changes made, and their distribution, control and recall procedures should also provide for approval by the organisation or person responsible for the design of all documents and changes in thereto in which the design is defined. Many reports [93,97] indicated that problems were encountered in construction which result from information prepared for communication from designers to site which is unco-ordinated, of poor quality, incorrect, missing information and not distributed where and when it is needed.

- Point six is also relevant to construction because this particular control could be applied in current building design practice, with regard to dimensional variability. The existing Code for Accuracy in Building [53] and its proposed successor 'Guide to Assessing the Risk of Misfit in Construction' [89], both cite 'permissible deviations' in the former and 'deviation limits' in the latter for dimensional accuracy for various constructed elements using different materials (i.e. spaces between blockwork walls) [60].

- In point seven particular attention needs to be paid to this aspect during design reviews - as no design and drawings could be passed by the planning authority if they do not satisfy these requirements.

- In the field of new materials, as point 8 indicates, the work of British Board of Agrement is worth noting.

- The last point (No. 11) is a task much neglected in design and construction [13]. The use of feedback information to eliminate repetition of identifiable defects in the existing property would reduce problems in the new constructed property under use.

The direct application of B.S. 5750 without adjustment to the design phase of the building project seems perfectly reasonable, and would reduce problems in the subsequent phases. This offers a real possibility of improvement in modern building technology because it addresses the 'processes' that result in the design 'product' which is the key phase that links 'briefing' to 'tendering/construction' and ultimately impacts upon the 'maintenance' phase of the total building project [89].

3.5.2.1.2 B.S. 5750 and the process of site management

There has been considerable debate about the relevance of B.S. 5750 to the construction industry in relation to not only the design process, but site management as well.

The quality assurance of products for construction is important, but is of limited help in reducing building defects. Problems are more likely to occur because of 'lack of quality' in installation or the design process as recent studies revealed [36,21].

The building industry increasingly depends on a wide range of specialist sub-contractors. The development of Quality Assurance Schemes by the relevant trade associations is an obvious route, but each branch of the industry contains a very wide range of firms, and there are obvious difficulties in development of schemes which would be acceptable to the industries and useful to the customers [125].

This section of the thesis looks at the more recent application of QA to site management with particular reference to B.S. 5750 and comments on its limitation.

The developments in 1983 led to attention being paid to the field of quality in the UK industries. It started in 1979, when the BSI published the British Standard for quality assurance systems [52], B.S. 5750. In 1982, then, the government published its White Paper 'Standards, Quality and International Competitiveness' [101]. In 1983, it launched the

National Quality Campaign as part of the overall effort of increasing the competitiveness of British industry in the field of quality.

One of the national establishments in the construction industry that has responded to government campaign is NHBC. Until 1983, the work of the NHBC was largely in the field of quality control (through specification and inspection), backed by insurance to further protect the house-buyer.

In 1983 the NHBC was approached by Mortiboys [209] who is the consultant to the National Quality Campaign run by DTI. He suggested that housebuilders could benefit from the Cost Effective Quality Management (CEQM) approach. CEQM is a new approach to management based on the fact that it is very expensive not to do jobs 'right first time'.

The basis of CEQM is that all jobs in a company can and must be done right first time. It is suggested that [209] the rewards of CEQM are great and include the following:-

a) Increase overall efficiency
b) Increase market share
c) Increase productivity

d) Increase competitiveness

e) Increase profits

f) Enhance employee morale

g) Enhance company image

h) Achieve registration to B.S. 5750.

The essential features of CEQM are:

(i) Top management commitment and leadership.

(ii) Clearly defined and understood corporate policies and objectives.

(iii) A CEQM system based on planning to do all jobs right first time.

(iv) A continuous improvement programme.

(v) Knowledge of the cost of mismanaging quality.

(vi) A desire for customer satisfaction.

(vii) Determination to operate efficiently.

As a result Mortiboys [209] was sponsored by the NHBC to carry out a pilot scheme to suggest how QA might be applied by a small number of house building firms. 10 separate firms were selected on a variety of housing contracts. They were selected from thirty seven on the basis of their company size, type and geographical location so that the scheme would be truly representative of a large section of the house-building industry. The firms were eventually satisfied that the QA systems they introduced had been a success and saved them money in reducing callbacks to defective work [209]. Some of the participating firms in the scheme commented as follows:-

"We were appalled by our administrative procedures. We had none. After consultations, we wrote down what we should be doing. Cost benefits are already apparent in our buying procedures, and improved quality is beginning to come through on site. The project has been a grate success."

"The project has raised morale, particularly as the views of second tier management have been thoroughly canvassed. As a result employees found themselves in much less unproductive work and client satisfaction has increased. We expect to see cost savings."

However, the consultant felt that B.S. 5750 did not go far enough:-

a) B.S. 5750 did not take into account the development of employee attitudes and ability at all levels in the company starting with the Chief Executive. Controls and systems cannot be used to make employees achieve the company's objectives. On the other hand, employees with the right attitudes and abilities will make systems work.

b) B.S. 5750 also falls short of the requirements of Cost Effective Quality Management in that it does not address itself to the early stages of business development, e.g. identification of market opportunities, market research or product planning.

c) Nor does it address itself to the later stages, e.g. after-sales service and information feedback on customer satisfaction.

Nonetheless, of the outstanding benefits of the scheme has been the way in which it has built on the willingness, the desire, for people in all parts of the company to work together if they are shown by top management that they are willing to take the lead by demonstrating total commitment to doing their jobs right first time. The scheme has also shown that given the right leadership from the builder, sub-contractors will react in the same way [209].

Several years of research into quality control has shown 13 broad causes of quality problems [21,36]. The pattern of their occurrence and the success with which they are solved is shown in Figure A (in the Appendix). It is the upper six causes (aspects of workmanship and site management) that are relevant to

Table A (in the Appendix). The table shows that proper application of the principles of QA could make significant inroads into each of the causes.

3.6 QUALITY ASSURANCE CERTIFICATION BODIES

The attainment of quality is enhanced by independent third party certification. By means of a certificate of conformity or a mark of conformity, this provides the assurance that a product or service conforms with specific standards or technical specifications.

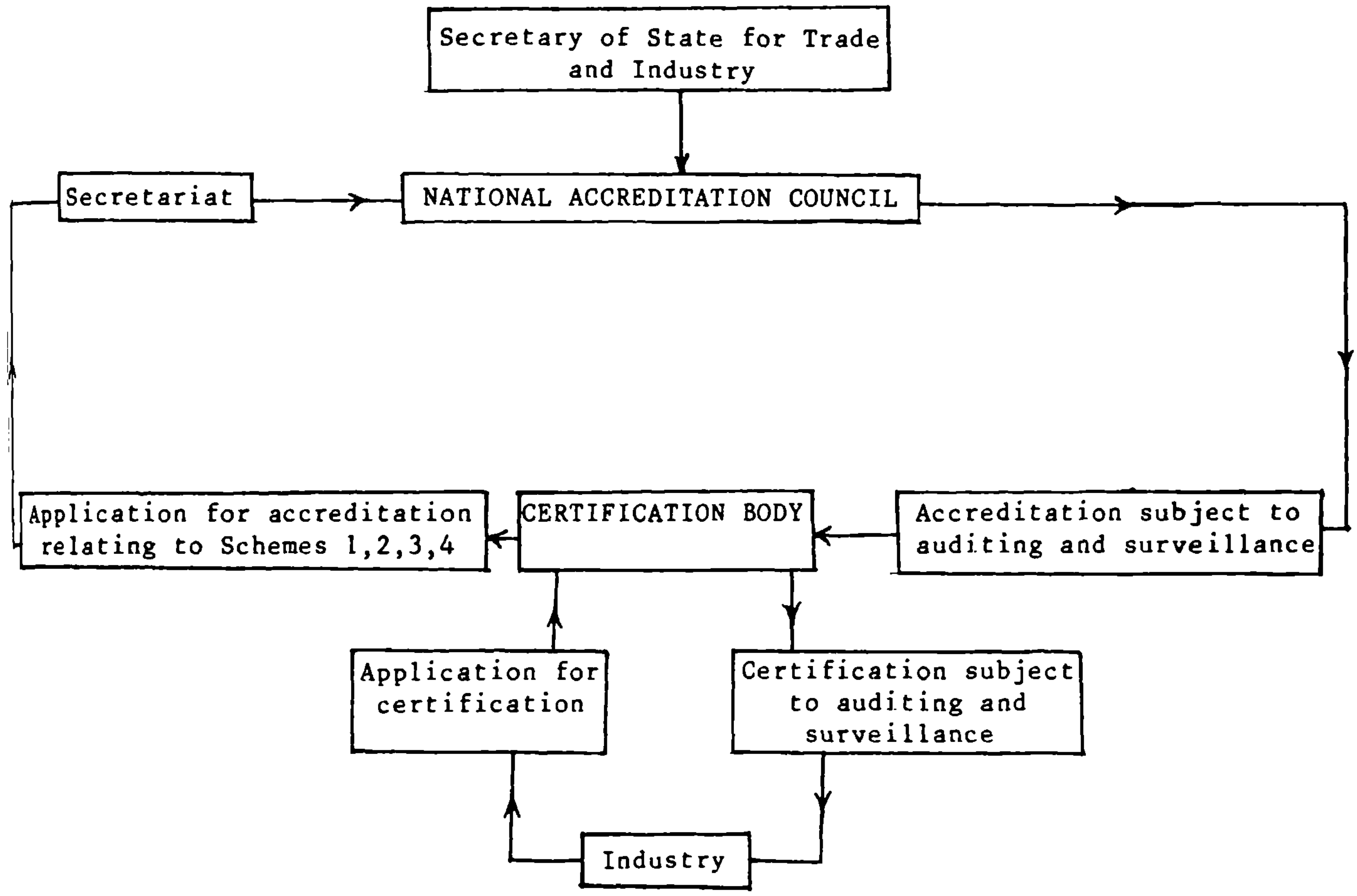
An organisation which supplies materials or services may seek certification that its Quality System complies with B.S. 5750 [80] from a certification body which is itself accredited by the National Accreditation Council for Certification Bodies (NACCB).

NACCB has been formed [236] in the UK whose main purpose is to undertake, on behalf of Government, the impartial assessment of certification bodies applying for Government accreditation . Accreditation has been defined [236] as the formal recognition by a national Government, against published criteria, of the technical competence and impartiality of a certification body or test laboratory.

The criteria against which certification bodies are assessed are based on international documents. This has been done to encourage the reciprocal recognition of certification schemes on an international basis.

Figure 4 shows the relationship between NACCB, Certification Bodies and Industry with respect to application by industrial organisations for certification of the indicated schemes. An individual firm may seek individual certification or, alternatively, certification within a sector where a Quality Scheme has been specifically developed for that sector. The route to certification under B.S. 5750 for an individual firm is shown diagrammatically in Figure 5.

CIRIA [80] has published the list of selected certification bodies who are likely to have an interest in quality assurance, but this has not been positively confirmed in all cases. Much information has yet to be collected and collated.



Key to Schemes

1. Quality Management Systems
2. Product Conformity Certification
3. Product Design
4. Quality Assurance Personnel Training

Figure 4: Relationship between National Accreditation Council, certification bodies and industry

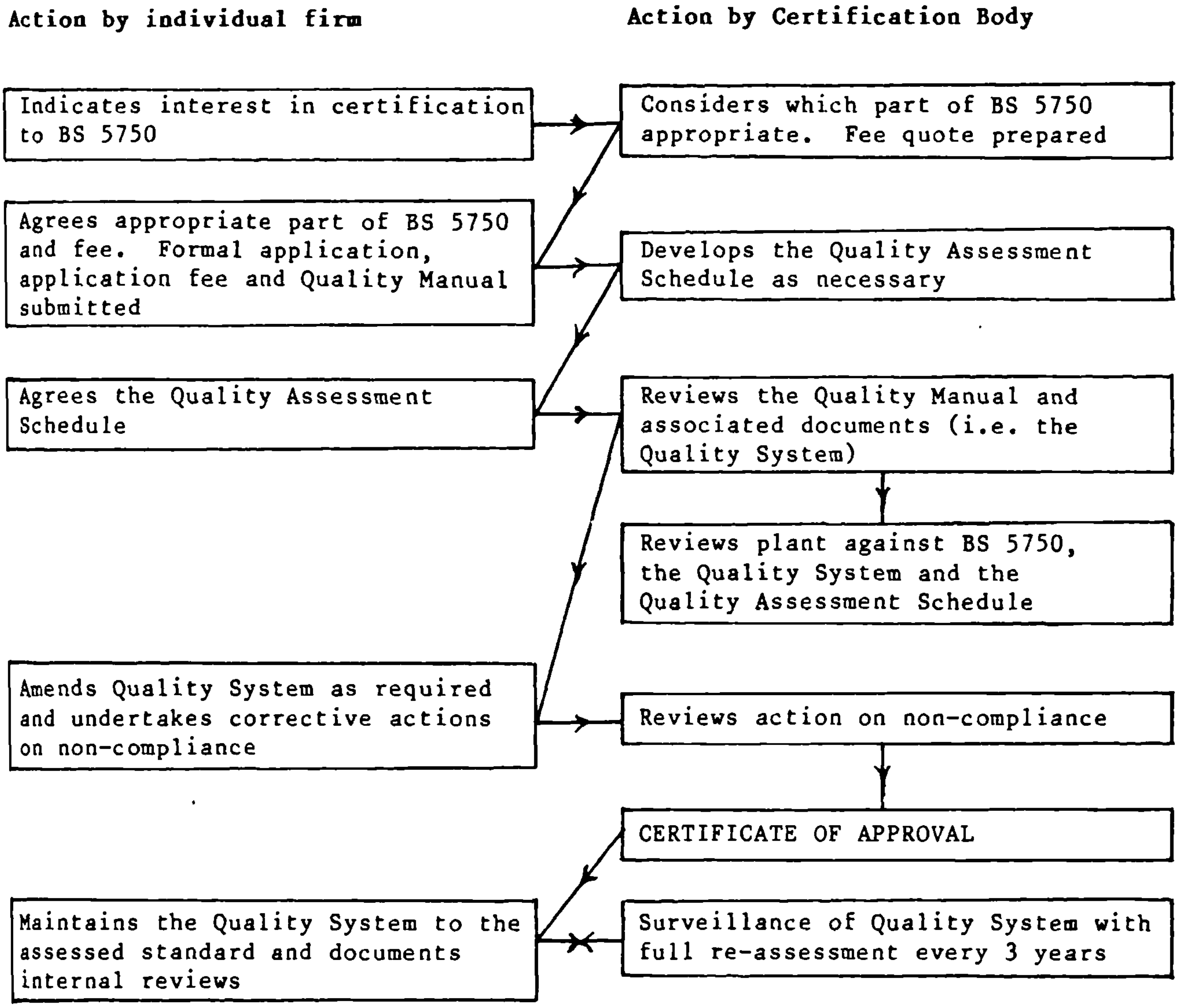


Figure 5: Route to BS 5750 Certification

CHAPTER 4

QUALITY ASSURANCE AND THE MANAGEMENT OF THE BUILDING PROCESS

4.0 QUALITY ASSURANCE AND THE MANAGEMENT OF THE BUILDING PROCESS

4.1 INTRODUCTION

In the building industry today, there are a variety of systems for organising the design, construction and commissioning of building projects. This is due to recent developments in increasing size of many projects, increasing technological complexity of such projects, more complex interdependencies and variations in the relationships among organisations and institutions and proliferating regulations and demands from government. A wide range of professional and contractual relationships are available according to the character of a project and the expertise required and there are rapid developments in site operations, use of components and assembling processes.

The management of the building process has been the concern, partially or totally of several studies. The problems of design and construction segmentation were highlighted and discussed with integration and co-ordination facility afforded by different approaches, for example, project management as remedy for particularly large and complex projects [210,211]. Walker and Hughes [274,275] and Walker and Wilson [276] have discussed issues of differentiation and integration. There is no one type of contractual method to satisfy every project. An approach has to be selected which is appropriate to the particular conditions which apply.

While the principles of quality assurance may be universal, application to the individual organisation is unique to that organisation, although there may be similarities within individual sectors (a 'sector' is defined here as part of the industry performing the same or similar function, e.g. architect, engineer, contractor). If application of quality assurance is to be discussed in depth, or comparison made, it is important to understand the functions of the individual organisations and sectors and how they relate to each other in terms of responsibility in their contributions to the built environment.

This section of the thesis attempts a brief description of the principal means by which the different organisations might come together in the UK to provide a building - what is usually termed 'building procurement'. The procurement routes available in the UK include:

(1) Client Build
(2) Design and Build
(3) Traditional Consultant Design, Contractor Construct
(4) Management Contracting
(5) Construction Management.

Each one will be briefly described as follows.

4.2 CLIENT BUILD (ROUTE A)

Historically, state public works departments, counties, central government agencies and private companies have performed both their own design work and some or all of the actual construction with their own forces. The client (sometimes known as 'customer', 'employer', 'building owner') has within his organisation his own building design and construction department. This is the simplest organisational model which can exist and where one quality assurance system could apply to the whole procurement process. The following conditions may however exist.

4.2.1 VARIATION A1 - CLIENT BUILD BY USING ONE CONTRACTOR

The client has within his own organisation the skills to design and/or co-ordinate but no actual construction skills. He contracts with one contractor to carry out the construction.

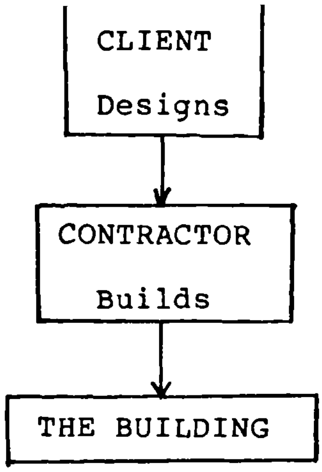


Figure 6: Client Build by Using One Contractor

4.2.2 VARIATION A2 - CLIENT BUILD BY USING SEVERAL CONTRACTORS

As Al above but the client contracts with separate specialist contractors (e.g. excavation, joinery, heating, etc).

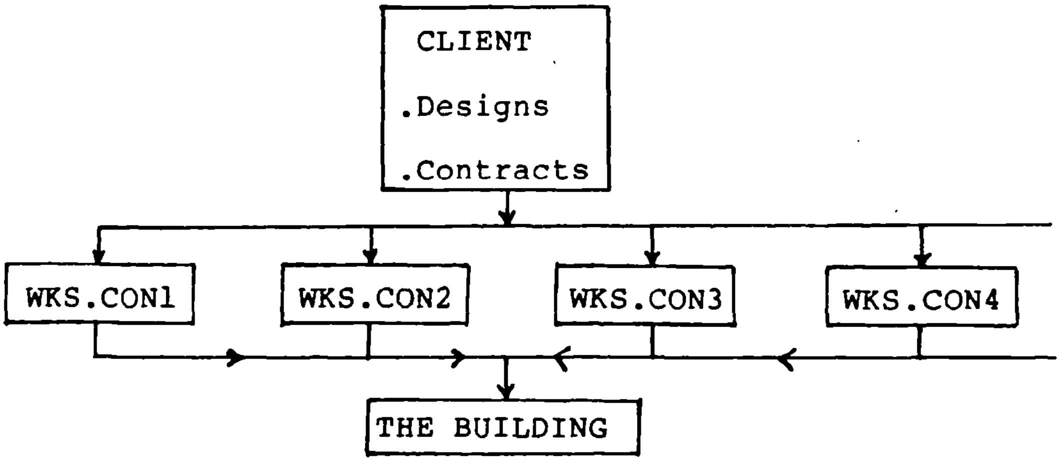


Figure 7: Client Build by Using Several Contractors

Routes A, A1 and A2 above are normally used when the client himself maintains his building stock and carries out small extensions; little design input necessary.

4.3 DESIGN AND BUILD (ROUTE B)

In design and build (sometimes known as 'design and construct', 'package' or 'turnkey') all phases of a project, from conception through design and construction are handled by the same organisation. The client appoints one organisation which takes total responsibility for designing and constructing the building. The design and construct companies tend to specialise in straightforward types of development, e.g. office or factory buildings, and often employ their own architects, engineers, quantity surveyors, construction managers and building staff. The design and construct approach can be utilised under just about any form of contract including lump sum, cost plus a fixed fee, cost plus an incentive fee and guarantee maximum price.

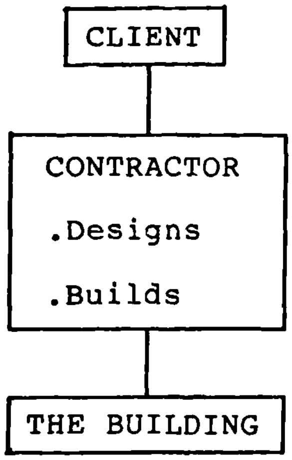


Figure 8 Design and Build

However, the following variations may exist in the above system.

4.3.1 VARIATION B1 - DESIGN AND BUILD WITH SUB-CONTRACTORS

It is unusual for the contractor to have all the skills necessary to construct the whole building, there the contractor sub-contracts some or even all of the packages.

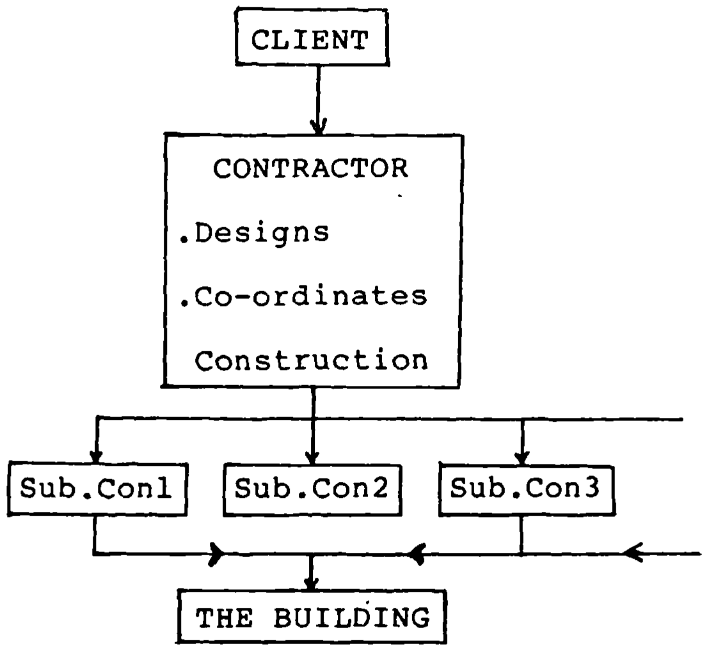


Figure 9   Design and Build with Sub-Contractors

4.3.2 VARIATION B2 - DESIGN AND BUILD WITH CONSULTANT DESIGNERS AND SUB-CONTRACTORS APPOINTED BY CONTRACTOR

Many contractors do not have design departments, or have design departments which cannot provide design skills for large more complex buildings. The contractor then appoints design consultants (architect, engineer, etc.).

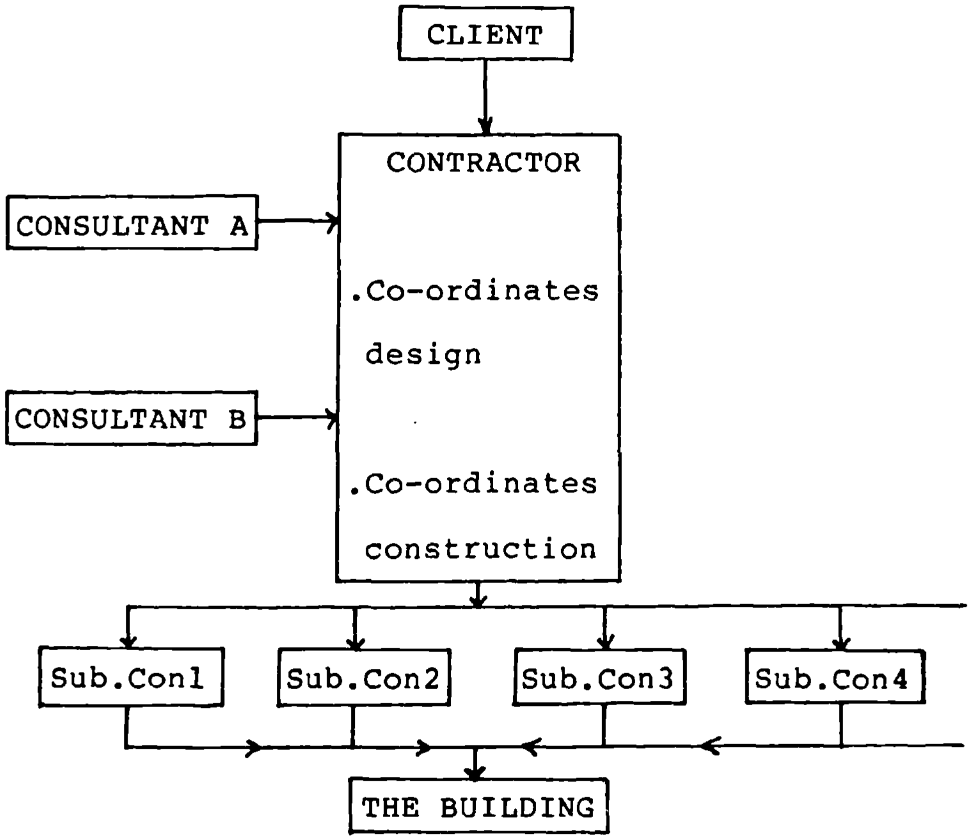


Figure 10 Design and Build with Consultants and Sub-Contractors

The above variations B1 and B2 are the most popular routes used by the housing sector except that the contractor builds separately and then seeks a client for his product.

It is stressed that in both variants the contractor remains entirely responsible, in the eyes of the client, the consultants and the sub-contractors are not recognised. Route B and variants B1 and B2 are popular in the UK and particularly appropriate for repetitive or fairly simple buildings, e.g. by private developers.

4.3.3 VARIATION B3 - JOINT PROJECT PARTNERSHIP

In this approach, the client still looks to a single legal responsibility for design and construction but here consultancy and construction organisations form a company to bid for and carry out a joint design/construction commission. The company only exists for the commission and is then liquidated.

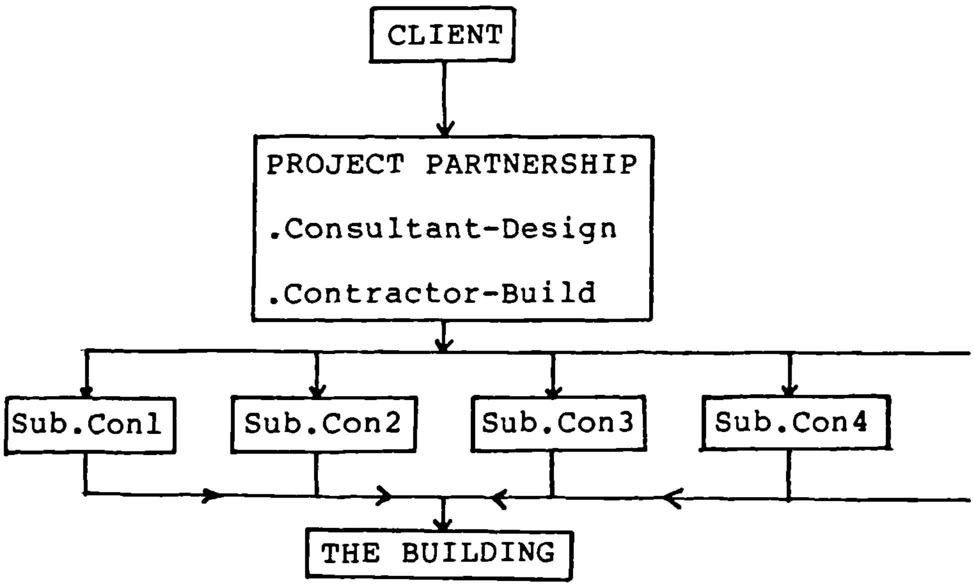


Figure 11 Joint Project Partnership

This variant of B is becoming popular in the UK for large prestigious projects where the client demands 'household name' design but a single responsibility.

4.4 TRADITIONAL CONSULT AND DESIGN, CONTRACTOR CONSTRUCT (ROUTE C)

Under the traditional method, the client appoints separate consultant designers (co-ordinated by one of them - usually the architect) and contractor. The contractor takes entire responsibility for construction but probably sub-lets as described in B1 above.

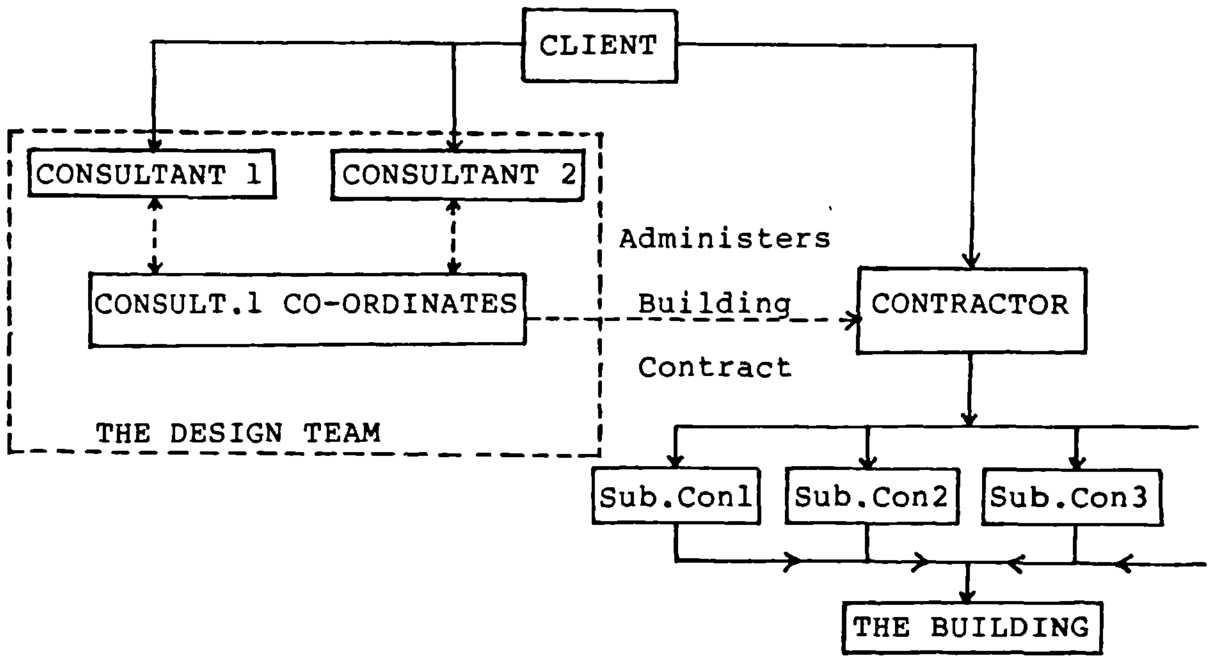


Figure 12 Traditional Contract Building

The above approach is still the largest and most popular route in the UK. It operates best where the building programme permits design to be completed before construction starts and for projects of some size and complexity. This type of approach was indicated to produce the root of most of the communication problems in the building industry as the responsibility of design was removed from the responsibility of production [157].

4.5 MANAGEMENT CONTRACTING (ROUTE D)

In this approach the client appoints separate consultant designers as in Route C above, but the "contractor" contracts with the client to co-ordinate the construction process and not to construct. This system unites a three-party team consisting of the client, designer(s) and the general contractor. As the construction professional on the construction team, the management contractor works with the designers and client, from the brief through to completion of construction, providing leadership of the construction team and on all matters relating to the production of the building with particular regard to time, cost and 'quality'.

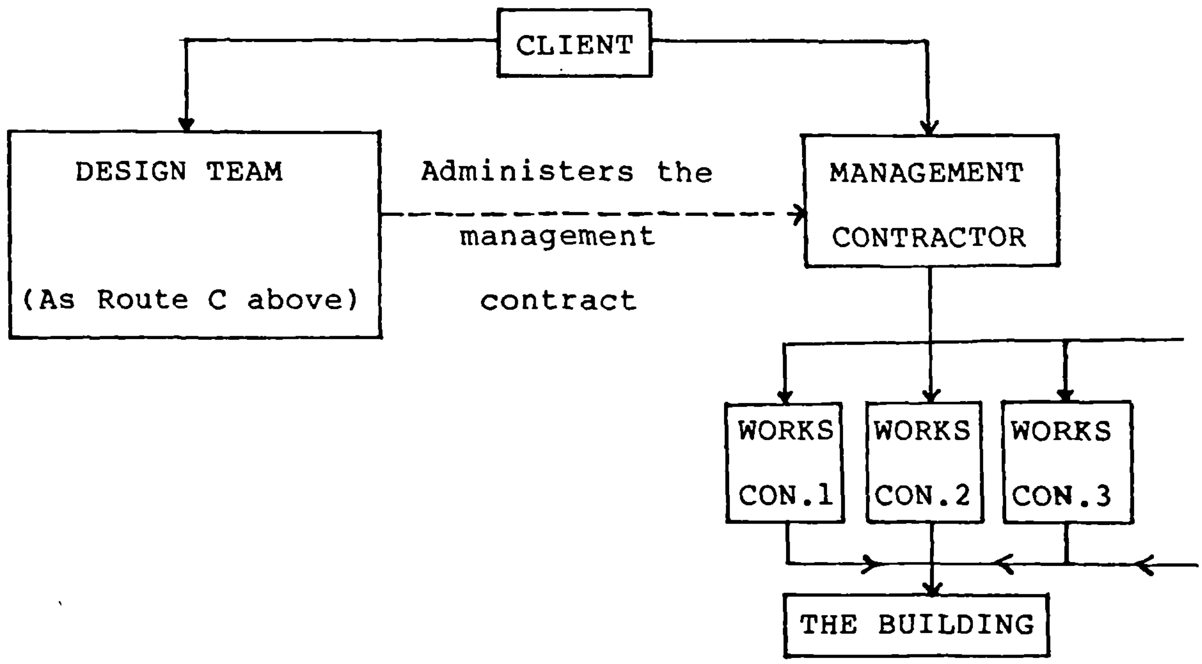


Figure 13 Management Contracting

The above route is particularly appropriate for fast moving projects where construction has to commence before design is complete.

4.6 CONSTRUCTION MANAGEMENT (ROUTE E)

In this approach the client contracts with each works contractor direct (i.e. not through a management contractor as in Route D above). He appoints a separate co-ordinator (who may be a design consultant or a contractor) to advise him on the appointment of the works contractors and their subsequent co-ordination. He appoints consultants traditionally to carry out the design. One of the consultants may also be the co-ordinator.

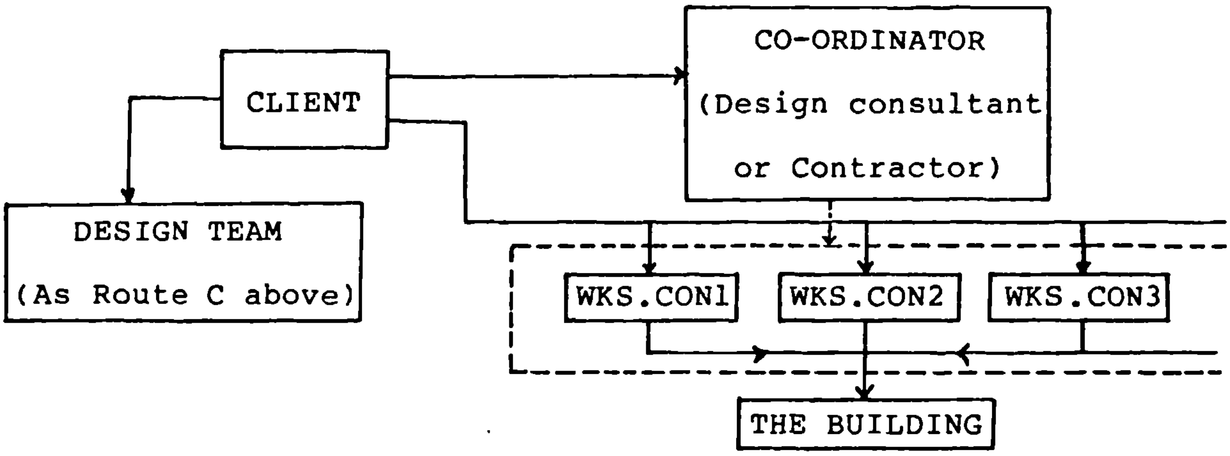


Figure 14 Construction Management

This arrangement is similar in principle to A1 above but used where the construction is large or complex. It is best suited to projects where the maximum flexibility is required of the design and construction programme.

4.7 CHOICE OF PROCUREMENT PATH

From the above possible routes, the members of the construction industry can therefore be brought together to give the client the services he requires. These alternative procurement paths vary in the way they work for clients. Each method is ideal for some aspects of typical client demand, whilst being weaker on others [216]. The supposition that the choice of a management method of the building process for the client may have ramification on the achievement of quality for a given project seems plausible. The way to determine which procurement path to use is to consider the priorities the client has for his project and check them against the characteristics of each path. However, better integration and co-ordination enhance communication and information flow efficiency and hence the facilitation of the design process and construction work on site.

Therefore, the client must control his contract in an environment where multiple organisational arrangements exist and where the work and interfaces of the various parties involved must be co-ordinated by appropriate measures with effective means of communication between himself and those to whom he has delegated the various tasks.

By definition good management includes good quality assurance practice. If the client is to receive/achieve the required quality in his completed building, then its design and construction must be controlled within a management system which will ensure that:

- the required quality is correctly specified;
- the specified quality is achieved;
- the achievement of the specified quality is verified; and
- all parties understand the requirements and the means to satisfy them.

To this end more client involvement is required to benefit the achievement of quality and if a greater proportion of building project is to run well. This involvement might be achieved by clients demanding much more descriptive and meaningful reports from the various parties they employ, or by appointing a representative who is to look after his interests.

In conclusion, it is the way quality management is devised and performed which provides the main quality assurance.

CHAPTER 5

SITE REALITIES AND THE ACHIEVEMENT OF QUALITY IN BUILDING CONSTRUCTION

5.0 SITE REALITIES AND THE ACHIEVEMENT OF QUALITY IN BUILDING CONSTRUCTION

5.1 INTRODUCTION

In recent years a good deal of attention has been directed towards the issue of how quality on site may be improved, given the proliferation of new products and processes and the complex and uncertain conditions under which the construction firm inevitably operates. Much of this attention has been focused upon close teamwork, work-place-supervision, communication and motivational correlates of improved site performance, and upon the role played by management - particularly site management - in creating and fostering appropriate conditions on site.

Historically, standards have been determined within the framework of well tried materials and technology, accompanied by long established and well understood procedures and relationships. The architect was able to design most, if not all of a building, and was seen to be the source of authority, backed up as necessary by the clerk of works on site. The contractors understood the conventions and relied on their own well trained, directly employed tradespeople to carry out nearly all the job and achieve the required standard.

The position has now changed dramatically with coming of specialist sub-contractors. Nearly all operatives on today's building sites are paid by results. Obviously there is nothing wrong with such incentive schemes provided the specified requirements upon which payment is to be made are clearly understood.

The inferences drawn from empirical studies and more general observation often point to the 'style' of management as being an important determinant of the level of quality achieved on construction sites via leadership, teamwork, communication, clearly understood line of authority and motivational consequences for the workforce and supervisory staff on site.

In particular many studies highlight the importance of leadership given by construction site management, and clearly understood line of authority, supervision and the lack of care exercised at all levels; and inadequacies in the quality, completeness and accessibility of the project information. It is suggested that efforts should be made to harness the effects that these will have upon the achievement of quality in site construction work.

In this chapter, the contribution of site management and the policing of standards to the achievement of quality in construction are examined. Drawing upon existing empirical studies and linking them with research findings in the social sciences, it is here argued that there is often insufficient attention paid towards the range of complex and interdependent variables that can influence construction site activities. As a consequence, the predictive capacity of such research study is limited, and the recommendations often derived particularly concerning appropriate managerial actions, often fail to account for significant variability in circumstances. The applicability of the concept of "leadership" to the construction site situation, and its relationship with key component variables related to behavioural factors (namely supervision satisfaction, motivation, morale, etc.) are singled out for attention.

5.2 LEADERSHIP ON CONSTRUCTION SITES

Although many people appreciate that managing people is an important part of their work, the human skills of management are often neglected in comparison with the technical demands of the job.

Quality on site needs good leadership. Unfortunately, choosing the most effective leader for a particular job is not always a deliberate process. He or she may come as 'part of the package' in the sense that the role is defined by the building procurement system chosen or by the size and organisation of the contractor.

One may ask, what is "leadership" in these circumstances, and what 'styles' of management or leadership create conditions conducive to enhance performance. Too often the conclusions drawn point to the outcomes to be achieved rather than to the specific ways in which different strategies may differentially achieve these outcomes. Borcherding and Garner [39] for instance conclude by advocating:

> "providing adequate support and assistance to the workforce and establishing a co-operative atmosphere among all levels and parties involved" (p.453).

Ferguson and Mitchell [121] have asserted that the essential quality of the leader is an ability to balance the needs of production against those of the people for whom he is responsible. In other words, in addition to making a significant contribution to the construction process, he should be capable of winning the respect and co-operation of the client, designer, general and sub-contractors, of their representatives on site and of the key craftsmen and technicians.

Several factors make social exchange a key concept in understanding leadership [173]. First, to have leaders we must also have followers; thus two or more people are involved in interactive relationships. Second, leaders and followers exchange influence.

Influence over others is purchased at the price of allowing one's self to be influenced by others. Followers depend on leaders for ideas, directions, and support. Leaders depend on followers for meaningful contributions towards organisational performance. On the basis of a survey carried out in business corporations, Licata [190], found six aspects that people want and expect from leaders:

(a) Credible communication - providing accurate information on matters essential to their well-being.

(b) Association with workers - being willing "to get their hands dirty".

(c) Fairness in sanctions - making disciplinary decisions justly, e.g. not punishing the group for the infractions of individuals.

(d) Ability to delegate - allowing those closest to a particular task to make the routine decisions about it (little vetoing and overruling).

(e) Ability to take initiative - anticipating significant problems and consequences and taking appropriate action in good time.

(f) Ability to command respect, or external confirmation - having a reputation for success (inside and/or outside the organisation) and clout in planning and budgeting matters.

By fulfilling these expectations, leaders increase the probability that their influence attempts will succeed.

Attribution of leadership is also summarised by Hinze and Keuchnmeister [159]. They identified four distinct 'styles' of leadership recognised in the social science literature though more often grouped into 'initiation'/ 'consideration' dimensions or 'concern for results'/ 'concern for people'.

It is interesting to note that Borcherding's [37] results tend to emphasise the 'consideration' dimension:

> "....there is little, if any, recognition for good quality or productivity and suggestions are ignored... craftsmen are made to feel inferior to the office staff...lower level supervisors, as well as management cause craftsmen dissatisfaction by constantly being on their back...allowing nepotism and friendship...in advancing craftsmen or assigning good work".

Indeed in analysing the role of foreman he concludes that: "recognition seems to be about the only way to provide an added satisfier-motivator for field supervision" [39].

This would seem to suggest three things; firstly that the scope for increasing satisfaction is greater if a more consultative and personally considerate managerial style is adopted. Secondly, that such a style is a counter-balance to the more dissatisfying consequences stemming from inadequate or inappropriate managerial actions. Thirdly, that the scope that site management has to improve morale and satisfaction is limited to the adoption of this style, to the extent that the organisation and structuring of site activity - possibly a 'directive' or 'initiating' style of leadership is the province of higher management personnel.

Indeed, research suggests the importance of interpersonal, as well as technical and administrative skills, in training for site management [129].

This has a number of important implications [45]. Firstly it suggests that 'leadership' in the context of a construction site is neither concentrated on site nor at head office. By concentrating upon the key role of foreman as a 'leader' of his crew, the point is missed that the 'function' of leadership including goal-setting and organising, co-ordinating work, etc. - do not necessarily come within his jurisdiction. However, the 'position power' of the leader in group-task situations has been shown to be a relevant variable in determining the extent to which his actions prove effective [123].

This consideration is especially important if one accounts for the tendency within the industry towards more extensive use of subcontracted firms and the growing proportion of self-employed and subcontracted labour [45]. To the extent that a substantial proportion of the workforce employed on site fall outside the formal jurisdiction of the main contractor's supervisory personnel, one would expect this to have implications for managerial techniques adopted to improve communications, motivation and morale on site.

As noted by NEDO report [219], there are no formal procedures which the site agent can follow in carrying out the responsibility for achieving the quality required on site. With coming of new technology and growth of specialist subcontractors mean that in practice the site agent is not always able to exercise judgement in matters of quality outside his field. In these circumstances the site agent tends to rely on others to do this job including trades foremen and gang leaders. Moreover, the problem is most acute with nominated sub-contractors for whom the agent feels less responsible, although contractually this is not so.

A second implication is that different 'style' of leadership are not necessarily mutually consistent or complimentary. The breakdown of elaborate planning and scheduling systems for instance is cited as one major cause of dissatisfaction, and Borcherding's [37] results consistently point to the alienating effects of a greater specialisation and administrative rigidity.

A third implication is that different styles of leadership produce different effects. This is born out in part by the results of 'quality improvement' mentioned earlier.

Fourthly, the results point to the prospect that the effects of different styles of leadership are dependent, in part, upon characteristics of the situation. Research on leadership styles has made clear the enormous range of variations in leadership styles that exist. Consequently, research into leader effectiveness continues, but with the supposition that there is no one best way to lead, and that the effectiveness of leaders vary according to the situation, including the personality characteristics of the leader and those he is expected to lead. It is such considerations that are largely absent from the bulk of the research reported in the construction management literature.

5.3 MOTIVATION FOR QUALITY IN CONSTRUCTION

To do a job properly each member of the workforce must have the necessary theoretical knowledge and practical skills: these must match the requirements of the job. However, qualification alone does not guarantee quality work: motivation to do the job correctly or 'right the first time' is just as important.

A great deal of research has been done on the subject of motivation, and one thing is very clear - all answers are not yet realised. The examples and theoretical constructs that will be described below on motivation were not based on field construction projects. Rather, they were based on manufacturing and other related industrial and experimental situations. They are illustrated here to highlight the background information on the subject, and to relate them to construction situation and point to their limited usefulness.

One of the most easily understood theories of motivation is that proposed by Maslow [202], called the hierarchy of needs. According to Maslow, there is a hierarchy of needs that begins with the basic psychological needs for food, rest, etc.

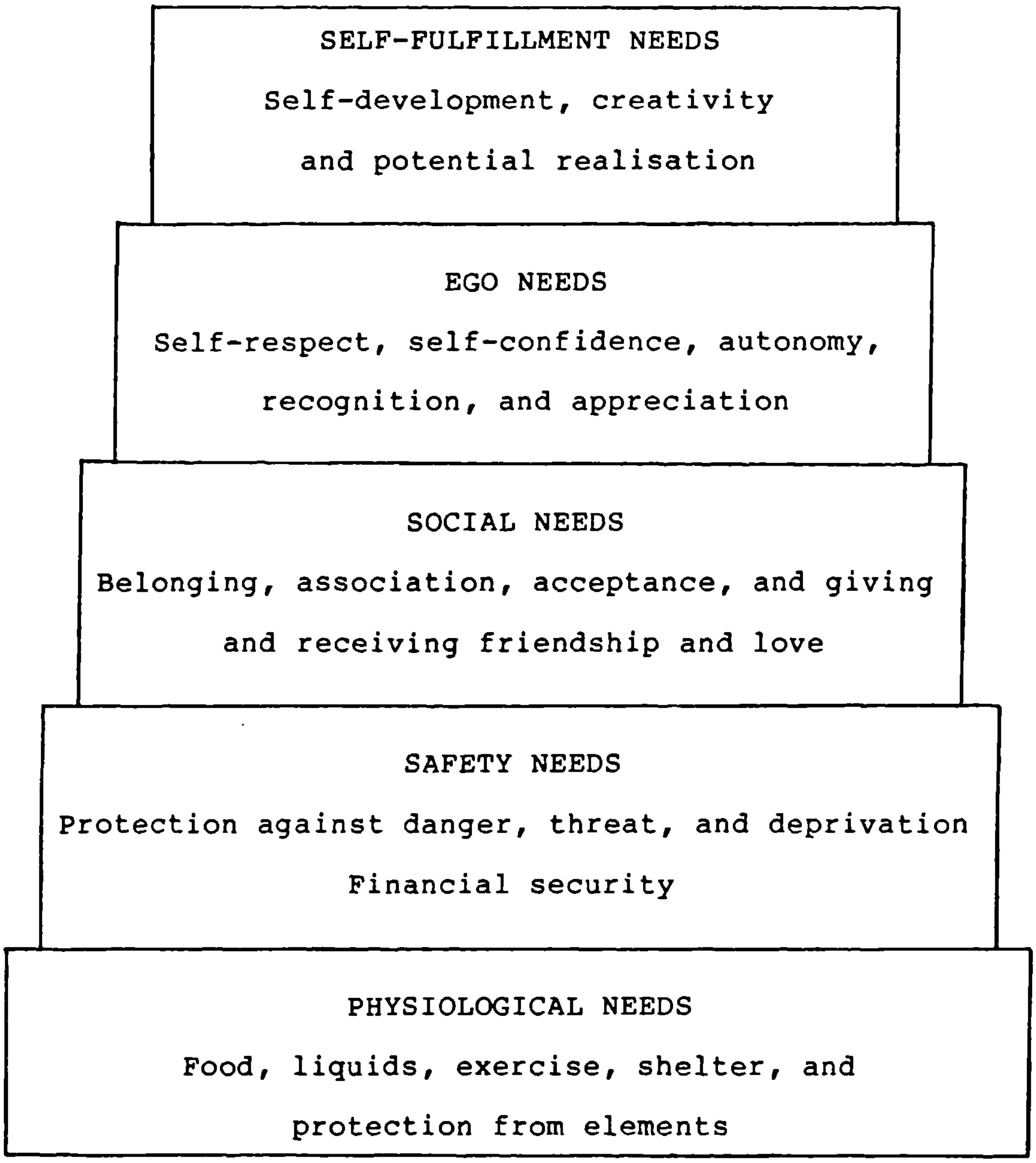


Figure 15: - THE HIERARCHY OF NEED

The Maslow's hierarchy of needs is summarised in Figure 15 above. A need is a motivator only if a person is deprived of the satisfaction of that need, otherwise, the need is unimportant. To activate a need of higher order, needs of a lower order need not be completely satisfied. In reality, an individual may be striving to satisfy several, or possibly even all, of his basic needs simultaneously.

Of particular interest is the universal findings that the more needs are satisfied, the less they motivate behaviour. In the construction industry, this is evident from some of the attitude changes over the last few decades among workmen [245]. A modern construction worker in a large city is not motivated by fear of his employer because his safety needs have been satisfied by his union and its working rules. Similarly, most modern construction workmen are earning sufficient money to gain them food, clothing, shelter, etc, and thereby satisfy their physiological needs. Consequently, many construction workers today are motivated by higher needs such as status or security. The status may take the form of a new job title with greater responsibilities [245].

McGregor [205] added additional insights on the satisfaction of man's needs as a means of motivation. Building from Maslow's assumption that satisfied a lower-level need is no longer a source of motivation, he concluded that traditional management techniques were not effective motivators. Traditional management approaches that emphasise direction and control through wages and job security are bound to be ineffective; they concentrate on the lower needs that are already satisfied, while ignoring the higher needs. McGregor refers to the traditional authoritarian management approach as Theory X. Arguing that the typical worker's performance is the result of a poor job environment and not his attitudes or expectations, he suggests a management approach that creates a work environment allowing the worker to seek higher level satisfaction for himself. This approach he calls Theory Y.

These approaches however have no "direct effect" on field construction; the best possible method appears to be the progressive Theory Y approach [151].

Herzberg [155] conducted much research that reinforces McGregor's theory that traditional management techniques are not good motivators. He finds that the only way to motivate the employee is to give him challenging work in which he can assume responsibility. Herzberg finds that certain factors - those that satisfy higher-level needs - are associated with job satisfaction. Other distinctly separate factors - those that satisfy lower-level needs - are involved in job dissatisfaction. The higher-level satisfiers associated with job satisfaction are found in the job content; they include achievement, the work itself, responsibility, and growth or advancement. The factors associated with job dissatisfaction are found in the job environment. These factors are related to the lower-level physiological, safety and social needs; they include company policy and administration, supervision, interpersonal relationships, working conditions, salary, status and security.

Of particular interest to this research project are supervision and interpersonal relationships.

Borcherding and Oglesby [37] have conducted an exploratory survey of job satisfactions and dissatisfactions in the construction industry, adding weight to the claim that construction workers can be effectively motivated. While they did not try to prove the Herzberg theory, they did drive satisfactions and dissatisfactions that agree with the theory. They found that job satisfactions for workers (tradesmen and apprentices) include complete tasks, good workmanship, productive day, physical exhaustion signifying a hard day of work, working on a tangible physical structure, and social work conditions.

Because satisfaction for the construction worker are consistent with the Herzberg theory, they concluded that dissatisfactions should also be consistent. Therefore, dissatisfactions should be those factors that derive from the work environment and which:

1. Prevent the workman from performing quality productive work or establishing meaningful work relationships necessary for his satisfaction; or

2. come into focus when higher level needs are not satisfied. This is indeed the case; dissatisfactions include poor interpersonal relations, unproductive workmen in crew, poor workmanship by crew, unfair job assignments, and repetitive work. Working with compatible members appears to be a most important factor. Effective motivation then appears to be quite possible in the construction industry.

5.3.1 SUGGESTED APPROACHES

Attempts to motivate workers to work effectively toward conformance to project requirements are exploratory at best, because little behavioural science research has been conducted in the construction industry. Numerous suggestions have been made to apply the findings and recommendations from industrial research, but these suggestions have not been well received nor implemented.

Among the suggested programmes for motivating construction workers are drawn from the concept of job enrichment. Job variety, delegated responsibilities, accountability for work, assignment of complete units of work, and specialised task development are common [234]. However, in the construction environment, most of the elements of job enrichment are already present.

Three basic principles are suggested [151] to improve the motivation of construction workers:-

1. develop healthy worker attitudes whereby workers look to the job and the contractor as a source of satisfaction. One way is to provide greater job security for the worker, and to develop faithful workers, management should keep good men from job to job and should plan to maintain a steady flow of work for its people.

2. administer praise and build respect - a common motivator often overlooked by supervisors. The consistent praise of good work could move the worker to produce quality work to satisfy higher achievement and recognition needs. It is important to workmen to have continuous feedback on their daily workmanship.

3. allow for the satisfaction of self-fulfilment needs. These may include improvement in management functions on the job, improve social relationships and to formally assign responsibilities. Supervisors and foremen can assign definitive responsibilities by giving workers specific tasks to complete with the understanding that the worker is held responsible. Perhaps the best approach to

assigning responsibility is to assign a major task to a crew and then assist them in planning and performing the work. This approach, known as participative management, allows for the satisfaction of many social, ego and self-fulfilment needs through the work itself. This participatory management technique can be applied to daily or weekly tasks and short-range goals.

In a study conducted in Western Germany [203], about 350 foreman of various firms were confronted with questions on certain aspects of quality and quality assurance. With multiple answers possible to the question: 'What do you think motivates people to do a good job?' the following emerged as most important:-

- 'sufficient and unambiguous information about the work to be done'
- 'good honest leadership'
- 'proper recognition of a job well done'.

Hayes [150], President of the American Management Association, draws our attention to an important fact of the motivation problem. He calls it the 'Pygmalion effect'. It simply expresses positive recognition - showing your employees that you see them as good, intelligent, productive, competent, and capable can have two important results: the employee's need to be recognised is fulfilled; the employees are more likely to feel capable, competent and efficient if they think that is how you see them.

Other suggestions to improve motivation of construction workers are reported by Mason [204], Neale [220], and Talbot [cf.151]. The articles were based on analysis of the need theories of motivation and on the application of these theories in other industries. The general conclusion was that the higher-order needs for belonging and growth possess the highest motivational potential for construction workers, and thus, should be promoted in the construction industry.

It is emphasised here that, the above suggested applications should not be considered as separate techniques, but as possible constituent parts of an overall approach. Research indicates [234] that these motivational factors must be viewed within a system of framework; one must take into account the inter-relationships and interactive effects among the various factors to understand the full effects of these factors.

5.4 ROLE OF MANAGEMENT

A major question, following the previous discussion, concerns the role of management in contributing to improved site performance. This is regarded as vital in managing motivational process at work [181]. So complex is the building process with even quite small jobs, that failure to get it right can impose severe penalties, especially in the area of quality. 'Getting it right' means working effectively with and through other people and of all the issues discussed previously, by far the most important are these of leadership and teamwork. To quote the recent NEDO report [219]: 'Problems on site arose mainly because of...poor organisation by the building contractor...or carelessness. Difficulties in putting the problems right were due to unclear responsibilities and lack of team working, motivation and commitment'. The report went on: Motivation and commitment to producing good work was a prerequisite for the achievement of quality and the most important factors which produce this motivation were concerned with management style. Good quality on site was associated with management which provided:

a) deliberately arrived at and clearly understood lines of authority
b) the active control, organisation and co-ordination of sub-contractors

c) the opportunity for section foreman and trades-foreman to contribute to, and to take some responsibility for, the broader understanding of how best to achieve quality on their site, and, possibly: the opportunity for informal discussions between various combinations of members of the building team.

The NEDO report [219] indicated a survey designed to identify why and to what extent the quality achieved on some typical one-off building contracts failed to match the expectations of the client, professionals and contractors involved. Appendix 4 indicates how well each project observed met these quality expectations. In the report it was indicated that, lack of skill of tradesmen produced comparatively few quality problems, as much a larger number being caused by lack of care. Carelessness by designers in the form of unclear or missing information on drawings also caused a great many problems. These are summarised in Figures A and B (in the Appendix).

The foregoing would seem to suggest that there is need for site management to improve morale and motivation.

Does better management lead to higher quality or productivity? The most compelling and direct evidence is provided by BRE study [21]. It concludes:

> "...quality depends on the ability of site staff to create an environment where good work could and was likely to take place. Sites with acceptable quality standards tended to be characterised by a 'consultative' approach to problem-solving - anyone on site could raise questions and many individuals could contribute to solutions - whereas sites with low quality standards tended to be 'non-consultative' with only the clerk of works really concerned with quality matters".

The theme of participative or consultative decision-making is also supported by Hinze and Keuchenmeister [159] who found that crews which rated high in productivity had foremen who allowed more participative decision-making. It really leaves little room for doubt about the link between quality and management.

While it has required some effort to piece together the evidence it does seem to be extremely likely that the effects we noticed in motor car manufacturing also exist in building. What this means is that once a strategic decision on the broad range of acceptable quality standards has been made, the actual quality achieved within that range depends on management competence.

It is interesting to notice that this is also thought to be the case in the Japanese car industry. The Nissan Motor Company have produced a very fine book called 'The Dawns of Tradition' [20]. In describing motor car manufacture it says:

> "To Japanese managers attitude is the most important intangible technology and heightening productivity demand good equipment and machines, but to an equal degree they need excellent relations between labour and management. The latter factor has close ties with workmanship".

What are the practical implications of these relationships? In beginning to answer this question we need to recognise that performance including the quality of the end product are determined by the craftsmen and specialists who actually build. Revans [239] provides much evidence to support the following propositions:

1. the intelligibility of the working task is the prime motivator to its enthusiastic and successful discharge.

2. the readiness of managers to listen to their subordinates - thereby enabling both manager and subordinate to learn how the working task may be more

successfully discharged - is the principal influence in making that task intelligible.

3. group leaders tend to pass on to their subordinates the treatment they perceive themselves to get at the hands of their own superiors.

4. that among managers of all ranks, the most important condition for professional success is that they shall understand how and by whom their targets are originally set.

5. when things happen at the work place that are either unintelligible in the first place, or that do not yield to correction on appeal, there is likely to be a failure of morale; this will manifest itself in ways such as: spoiled work; unmet schedules; absenteeism, accidents and disputes.

These propositions tell us quite simply that if we want 'good quality buildings' at sensible prices produced quickly we must ensure that the craftsmen and specialists understand what they are to build and accept it as sensible.

Other evidence points to positive correlations between the quality of on-site managerial supervision and crew work rate [45] and to a relationship between the method adopted by foremen in handling their crews and injury rates on sites. Such results are taken to indicate that improved site performance - and perhaps, quality, absenteeism, safety and turnover [244] are determined to a significant extent by the supervisory practices of site management personnel.

5.5 INSTRUMENTATION FOR QUALITY CONTROL

After the award of the contract, both the client and the contractor have to develop organisations capable of obtaining the desired quality level and to maintain the integrity of the design.

In the U.K., in most contract situations, the policing standard is that over all responsibility for ensuring that the appropriate quality is achieved rests with the architect/group leader/supervising officer, but this person is generally not good at recognising poor working practice and rarely present on site to enforce good quality [219]. As a result the job is often nominally delegated to a 'Clerk of Works' who is usually a former trades foreman or site agent. However, the precise role of the clerk of works is rarely discussed and agreed at site level and he is seldom given the authority he requires if he is to play a more positive and effective part in quality control.

Newlove [221], Fern [122], Black [33], Woodhouse [291], Freeman and Bentley [127], Bonshor and Harrison [36], Bentley [21], NEDO [219], Pickavance [232], Burnell [59], Vivian [271], Johnstone [170], Ferguson and Mitchell [120], expressed the opinion that the clerk of works is responsible for and limited to duties of inspection which are not defined, but which must be less than the otherwise associated with his work. Under the JCT 80 Standard Form Clause 12 a role restricted to that of an 'inspector' is specified [263]. The clause states that, 'the clerk of works' duty shall be to act solely as an inspector on behalf of the employer under the directions of the architect.' NEDO report [219] has noted that experienced clerk of works, who know what is needed to make a job go well, are even less likely to step outside their brief and help because they know the contractual dangers if they do not have the authority conferred on them by the architects.

It was worthwhile to pause, and briefly look at certain attributes the clerk of works must possess if he is to be successful in his function and in his contribution to quality control on site. An attempt is also made to summarise his duties outlined in many publications.

To begin with, the clerk of works must have a real and comprehensive understanding of the contract drawings and requirements, the contract law as it affects the site function, and the presence to command respect from the site operatives. He needs to have a sound knowledge of every aspect of the construction process, and the materials to be used to be able to easily and in an accomplished manner, recognise if they are appropriate and in accord with the specification. He should have a comprehensive understanding of the architects function so as to be an asset rather than work in isolation.

In a 'Handbook for Clerk of Works' [137], the function of the Clerk of Works is described briefly as:

> "To inspect in detail
> To report concisely
> To interpret clearly
> To record completely

and by this means to carry out his part in the job Architect/Clerk of Works team which has such an all important role in site supervision".

His duties are defined as to be:

> "the representative of the Architect on site for the day-to-day detailed inspection of works in progress, to ensure that such works are executed in complete accordance with the contract documents and with the instructions issued from time to time by the architect-in-charge. He is to see that the specified

> standard of workmanship is maintained: that the materials used are of specified quality: that construction throughout is sound..."

The Clerk of Works Manual published jointly by the RIBA and ICW [73] sets out clearly that: "the Clerk of Works is responsible to the architect. He acts as an inspector on site to ensure that the architect is made aware if the contractor deviated from carrying out the works in strict accordance with the contract documents".

The Clerk of Works' authority, says the manual, should be established to obtain samples of materials, tests of samples, samples of workmanship, BSS Certificate for materials and the storage of materials. He should inspect all work in progress, materials delivered on site, and test and submit for test materials scheduled in the contract. Also he should maintain records of tests made, of materials used which vary from the bills of quantities, and inspections carried out to sections of work completed.

Similar duties are also described for the clerk of works by SSHA [248].

The Standard Form of Building Control [263] requires, Clause 8.1-8.2:

"All materials and products delivered to site should be inspected by the clerk of works to ensure these comply with the specification. He should also insist to the contractor that materials, etc., are stored in accordance with the contract".

Johnstone [170] lays emphasis on the advantage of inspecting and even testing samples at an early stage in the contract. These he asserted can be twofold: in the first instance it makes those who are providing the items much more aware of the inspection procedures they must meet: and secondly, suppliers and manufacturers generally appreciate an interest in the products at this stage, as it helps them to determine exactly what is expected of them within the specification. It also provides better communication between the parties involved, helping to promote a better understanding throughout the contract, and encouraging everyone to remain aware of the cost implications.

Over the past few years BRE [21,22,36] has carried out several surveys on various sites. The reports all seemed to concluded that:

"...a factor often seen to be crucial in the achievement of effective quality control was the relationship between the person responsible for quality control (usually a Clerk of Works) and the

> site manager...Clerks of Works and site managers usually made decisions on quality with little guidance from outside the building site...the influence of clerks of works, and to some extent the authority of site managers was largely determined by force of character combined with the threat of the withdrawal of "goodwill" in their dealings with each other...the clerk of works had more leverage in this respect since as project information was rarely on time, totally complete or without mistakes, site managers relied upon Clerk of Works to help in filling in gaps in the project information, to undertake the time-consuming process of contacting the architect's office and sometimes to augment their own experience and ability".

Summing up, the aforementioned seemed to suggest that the clerk of works has a vital role to play in the achievement of quality in construction at site level and he needs to be given the authority congruent with his responsibility and have the architect/employer management support.

PART THREE:
SCOPE AND METHOD

CHAPTER 6

METHODOLOGY

6.0 METHODOLOGY

6.1 INTRODUCTION

After introductory discussions with the author's supervisors, the following major steps were taken:

a) an initial period of desk research began early in January 1985 to identify information sources and review existing literature on the subject.

b) A number of organisations were consulted to seek their views on the nature of the problem and to obtain lists of publications relevant to the field of study. Many of them replied favourably (see Appendix 5).

As a result, the author had the opportunity to have discussions on the subject with Mr. R.B. Bonshor, and Mr. M.J.C. Bentley, both of BRE at their Research Station offices in Garston, Watford. They both conducted separate field research on quality of work on construction in the last seven years and are currently engaged on other research programmes in construction quality. This gave invaluable ideas, directions and information on the subject.

Other invaluable ideas and information were gathered through the writer's participation in Building Quality Trust Meetings organised by the Department of Construction Management, University of Reading (see Appendix 5).

c) A series of initial interviews with a number of Housing Associations in Edinburgh, to explore the current situation and key issues regarding the control of their construction of new building projects, to ensure the quality of their completed buildings.

d) Conferences and seminars on Construction Quality Management at various points in time during the research study were attended here in the UK. Useful information was obtained and contact established with other people interested in the field of study.

6.2 INFORMATION SOURCES

In order to get the names, addresses and telephone numbers of the intended participants for the research project, visits were made to "the Housing Corporation in Scotland; Scottish Head Office", Rosebery House in Edinburgh.

Discussions were held with senior officers in the Head Office, pertaining to the intent of the research project. As a result the following publications were obtained:-

a) Directory of Housing Associations, Registered with the Housing Corporation in Scotland, July 1985.

b) The Housing Corporation Report 1984/85, Scottish Statistical Supplement.

c) Directory of Housing Associations, Registered with the Housing Corporation in Scotland, August 1986.

d) The Housing Corporation Report 1985/86, Scottish Statistical Supplement.

e) The Housing Corporation Report 1986/87, Scottish Statistical Supplement.

The above sources were used to extract the names of the associations receiving funding in the respective periods for the construction of new projects, for both preliminary investigation and main data collection.

f) National House-Building Council (Scotland), Annual Report and Scottish Register of Builders and Developers, 1985/86.

g) National House-Building Council (Scotland), Annual Report and Scottish Register of Builders and Developers, 1986/87.

In addition, the Scottish Federation of Housing Associations Edinburgh Office was contacted regarding the intent of the research project. As a result, an article was published in the 'Scottish Federation News Magazine, November 1985' asking for co-operation from the associations to participate in the research project.

6.3 PRELIMINARY INVESTIGATION

The first step taken to test the final questionnaire for data collection was to establish the feasibility of obtaining access to Housing Associations, to enable search for a sample of associations with contracts for new building projects currently in progress. This would lead us to contact the consultant building designers for their projects and the contractors working on sites.

Names of the designers and the contractors working on sites were received from the clients (the associations). Arrangements were made to visit the designers and respective site agents/managers either through the associations or directly; or to send the questionnaire by post. The aim was to administer the questionnaires for pretest purposes.

The two sets of questionnaire documents - Building Designer Questionnaire One and Construction Site Questionnaire Two, Parts I to IV are given in Appendix 1. All the questionnaires were prerecorded for identification purposes before distribution.

Many of the respondents asked for the questionnaires to be left with them for a few days before collection. Some were supplied with postage prepaid address envelopes for posting back to the university.

For some remote areas, the questionnaires were sent directly by post with postage prepaid address envelopes for the return of the questionnaire.

On many large projects, there were site agents/managers and their assistants, and the latter take charge of site activities in the absence of the former. Hence they were suitable respondents. In many occasions, a telephone call was made to the respondents concerned a day or two before collection.

This was to serve as a reminder, and it was believed the latter could have the intended effect of increasing the response rate.

Table 1 presents the response rate for the pretest sample. Two of the clients contacted had only one project each on site, and the rest had either two or three on separate sites. For the Building Designer Questionnaire One, 20 questionnaires were returned out of a total of 25 delivered. This gives an overall response rate of 80%. For the construction site Questionnaire Two, 80 out of a total of 107 were returned, thus giving an overall response rate of 75%. Out of the 80 returns, 20 were filled by site agents/managers, 20 by foremen category, 20 by site operatives and 20 by Clerks of Works.

The two response rates were considered high.

6.4 QUALITATIVE VERSUS QUANTITATIVE RESEARCH WORK

A considerable body of opinion exists over the appropriateness of various methods and methodological stance for conducting research. One debate of growing interest centres on the distinction between quantitative and qualitative methods.

Quantitative methods centre around techniques of randomised experiments, paper and pencil "objective" questions etc., and statistical analysis. In contrast, qualitative methods include case studies, in-depth interviews and participant observation. Some opinions were expressed supporting each side of the debate.

Table 1 Response Rates for the Pretest Sample

CLIENT	PROJECT Number	BUILDING DESIGNER QUESTIONNAIRE ONE			CONSTRUCTION SITE QUESTIONNAIRE TWO PARTS I TO IV		
		Number Delivered	Number Received	Response Percentage	Number Delivered	Number Received	Response Percentage
1	1	1	1	100%	6	4	67%
	2	1	1	100%	10	6	60%
	3	1	1	100%	4	4	100%
2	1	1	1	100%	8	6	75%
3	1	2	1	50%	6	5	83%
	2	1	1	100%	7	6	86%
4	1	2	1	50%	4	4	100%
5	1	2	1	50%	8	4	50%
	2	1	1	100%	4	4	100%
6	1	2	1	50%	5	4	80%
	2	1	1	100%	7	4	57%
7	1	2	2	100%	9	8	89%
	2	2	1	50%	4	4	100%
8	1	1	1	100%	6	4	67%
	2	2	2	100%	6	4	67%
9	1	1	1	100%	5	4	80%
	2	2	2	100%	8	5	50%
Total	17	25	20	80%	107	80	75%

Campbell [64], Campbell and Stanley [63], and Riecken et al [240] are often cited as staunch proponents of quantitative methods. Although Campbell and Stanley [63] were not primarily concerned with evaluation research, they describe this method as "the only way of establishing a cumulative tradition in which improvements can be introduced without the danger of a faddish discard of old wisdom in favour of inferior novelties". Riecken et al [240] expressed the view that "this method not only leads to clearer causal inferences, but the very process of the research design helps to clarify the nature of the social problem being studied".

Among others, Miles and Huberman [208], Weiss and Rein [284], Parlett and Hamilton [229], and Guba [138] are on the side of the debate supporting qualitative methods. They suggest several alternative research strategies deriving from the qualitative tradition which they believe "in general to be superior to quantitative design as a methodology for evaluating broad-aim programmes". In speaking specifically of education evaluation, Parlett and Hamilton [229] quite forcefully add:

> "characteristically conventional approaches have followed the experimental and psychometric traditions dominant in educational research. Their aim of achieving fully 'objective methods' has led to studies

> that are artificial and restrictive in scope. We argue that such evaluations are inadequate for elucidating the complex problem areas they confront and, as a result, provide little effective input to the decision making process.
>
> ....Illuminative evaluation is introduced as belonging to a contrasting 'anthropological research paradigm'."

Other view expressed on this topic is not merely as a disagreement over the relative advantages and disadvantages of qualitative and quantitative methods but as a fundamental clash between methodological paradigms (cf. Guba [138], Parlett and Hamilton [229], Rist [241] and Wilson [287]). According to this view, each method-type is associated with a separate and unique paradigmatic perspective and it is these two perspectives which are in conflict. As Rist [241] states the case, "Ultimately, the issue is not research strategies, per se. Rather, the adherence to one paradigm as opposed to another predisposes one to view the world and the events within it in profoundly differing ways".

Without attempting to be exhaustive, in brief, the quantitative paradigm is said to have a positivistic, hypothetico-deductive, particularistic, objective, outcome-oriented, and natural science world view. In contrast, the qualitative paradigm is said to subscribe to a phenomenological, inductive, holistic, subjective, process-oriented , and social anthropological world view (cf. Cook and Reichardt [87], Trend [265], Maanen et al [196], Hoinville et al [160]).

The next section in this chapter, discusses the utilisation of Quantitative Methodology in this research.

6.5 THE RESEARCH METHODOLOGY - "QUANTITATIVE APPROACH"

As noted earlier, the current debate over methods creates the impression that the researcher must not only choose a method because of an allegiance to a paradigm but must also choose between the qualitative and quantitative paradigms because those are the only choices available. The choice of research method should depend at least partly on the demands of the research situation at hand [87]. Before enumerating the reasons for the quantitative approach to this research methodology, it is worthwhile to further discuss quantitative research itself.

Quantitative methodology is founded upon the positivistic tradition, where the central tenet is the view that all study of society and human behaviour should be scientific in the mode of the natural sciences. Hughes [?] expressed the view that, the distinction between the social and natural sciences more reflects a matter of convenience;

there is no dualism in the world, but simply different aspects of the same underlying natural phenomena (cf. Walker [273], p.9). He went on, '...another fundamental belief shared by positivists is the view that the social and natural worlds conform to certain fixed and unalterable laws in an endless chain of causation' (Hughes [?], p.19) (cf. Walker [273] p.9). Kerlinger [175] has asserted that the aim of scientific method in any inquiry is basically to explain natural phenomena and discern causative patterns existing among variables. He went on to summarise scientific approach to inquiry:

First there is an indeterminate situation crying out to be made determinate. The researcher experiences vague doubts and inchoate ideas. He struggles to formulate the problem, even if inadequately. He studies the literature, scans his own experiences and the experiences of others. Often he simply has to wait for an inventive leap of the mind, maybe it will occur; maybe not. With the problem formulated, with the basic question or questions properly asked, the rest is much easier. Then the hypothesis is constructed, after which its empirical implications are deducted. In this process the original problem and, of course, the original hypothesis, may be changed. It may be broadened or narrowed. It may even be abandoned. Last, but not least, the relationship expressed by the hypothesis is tested by observation and experimentation. On the basis of the research evidence, the hypothesis is accepted or rejected. This information is then fed back to the original problem, and the problem is kept or altered as dictated by the evidence.

What is important in scientific research is the controlled rationality as a process of reflective inquiry, the inter-dependent nature of the parts of the process, and the paramount importance of the problem and its statement.

Another view is by Labowitz and Hagedorn [179] who expressed that "the major goal of scientific research is to establish causal laws that enable us to predict and explain specific phenomena. At a minimum, to establish these laws a science must have reliable information or facts" (cf. Walker [273], p.9).

The facts and information in scientific inquiry could be obtained by measurement through an appropriate technique. By any reasonable standard, measurement has been and continues to be a principal concern in the social sciences and other related research topics such as this, and as pointed out by Anderson et al [7], this attention is warranted. They stated four types of issues that are especially important. First, there are philosophical concerns, issues belonging to epistemology and the philosophy of science. ...what is the nature of measurement and what is its role in the scientific process? Second, classical measurement theory, coming mainly from the psychometric literature, has concentrated on reliability and validity. (This is the area more relevant to this research study). A third area, the theory of measurement, of a relatively recent field of endeavour aimed at developing formal models of measurement. Fourth, social scientists have devoted a considerable amount of attention to specific techniques for constructing measurements, that is, methods for obtaining measurement of unobserved variables from responses to questions.

Social and psychological phenomena could be studied scientifically and that to do so it is necessary to measure. The important point here is that one does not need to go to the extreme position of classical operationism, which argued that the only meaning of a concept is its operational definition; to appreciate that we have to measure in order to evaluate our hypothesised relationships, to confirm or reject them. Rather, by turning abstract concepts into measurements, we have available a rich repertoire of mathematical techniques that introduces precision, economy of thought, and powerful tools of analysis.

A fundamental requirement prior to measurement and data collection in research study, such as this, is the conceptual and operational definition of concepts or variables and the desire for empirical testing of explanatory theories.

The importance of measurement in quantitative approach to research is encapsulated in the statement by Lord Kelvin:- "when you can measure what you are speaking, and express it in numbers you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind" (quoted in Harvey [?], p.307-8) (cf. Walker [273], p.9).

The growth of interest in measurement in quantitative research is relatively recent. As pointed out by Bohrnstedt and Borgatta [34] this approach to research setting has the support of well formulated and proven statistical analytical techniques, and it is common now for research papers to report data on reliability and validity supporting their arguments.

As noted earlier, the subject matter and sort of people to be studied have bearing on the choice of method, the quantitative research methodology was utilised in the present study because of the following reasons:-

(a) The data to be collected for the research involved job characteristics, social psychological, organisational and individual variables in given project circumstances, data collection via questionnaires seem more appropriate, is quick, manageable and the most cost-effective way of collecting this type of information.

(b) Construction project organisation both at design stage and site level involve very complex human systems, and no individual ever has complete information about all of the things that take place within them. It is therefore felt, one method for capturing this complexity is to collect information through sets of selected research variables from participating members or some adequate random sample. This provides some information that can only be meaningfully collected at the individual level. As participants-observers, the members are uniquely qualified to describe the work, work environments, and organisational activities in their respective areas of the organisation. As active members, they are uniquely qualified to report their own personal beliefs, opinions, expectations, and effective responses that may, in aggregation, reveal important attributes in a given situation. Of course, once the information is collected, it should be remembered that the next problem is to do with summarising the complexity of the data collected, but the summary at least can be based on a decision about what is most important to describe and the information does exist to allow other summaries if at some future date these should prove appropriate.

(c) The quantitative methodology is utilised because it has the support of a set of well formulated and proven statistical analytical techniques which is much valued tool in data analysis (Leedy [186], Bohrnstedt and Borgatta [34], Zeller and Carmines [293]).

(d) Quantitative methodology is widely used in other research settings, e.g. psychology, organisational behaviour and organisation change and other social science disciplines.

The possibility for utilising qualitative research methodology was considered, but it was rejected because of the following reasons:-

(a) Qualitative research methods include, case studies, in-depth interviews, group discussions and participant observation. In the case of the in-depth interview, it is a quite laborious and time-consuming process on both the researcher and the respondents. Most architects and site personnel contacted were not ready for this exercise - time is of the essence.

(b) For case studies the researcher needs to have adequate number of projects under observation to have enough information that allows acceptable analysis. Efforts were made to that end, to get a substantial number of ongoing housing projects without much success.

(c) Williams [286] has suggested that a semi-structured questionnaire may be used when some of the flexibility and detail of qualitative research is required in conjunction with the opportunity to aggregate answers (the hallmark of quantitative research), for example when interviewing minority groups who are expensive to contact - in the case of this study, architects and site personnel who unequivocally will not permit their workflow and productive time to be disrupted. He went on ".....while such studies combine some of the advantages of both qualitative and quantitative research, they also combine their disadvantages; the analysis in particular can be extremely difficult and time-consuming".

Quantitative data collection via questionnaires was therefore decided to be utilised in this study, and the rationale for questionnaire approach is discussed in the section that follows.

6.6 RATIONALE FOR QUESTIONNAIRE APPROACH

The decision to use a questionnaire to collect information about individual perceptions was based on the relative advantages and defects of this methodology. The defects are well known: valid responses depend upon the clarity of the questions and the linguistic competence of the respondents. The questionnaire method - even when modified by the use of open-ended response opportunities - imposes upon the respondent a predefined array of topics and response categories that may not fit the 'real' situation of the respondent well. Responses may also be inadvertently biased or knowingly distorted. Handyside [143] has noted that questionnaires may end up in misleading responses resulting from flippant or dishonest answers which would not be given at interviews; misleading questions leading to misleading answers and bias by non-response because people will not answer questionnaires. Kerlinger [175] also pointed out defects in questionnaires. He stressed that this method of data collection is characterised by poor response rates, and the inability to verify responses given on the part of the research. Miles and Huberman [208] also recognised that when a questionnaire is used one cannot resolve any of the respondents' queries or incomplete answers whilst one assumes that the questionnaire reaches the correct person. Brook [50] has indicated another defect in questionnaire methodology - "the inability of self-completion questionnaires to convey complex definitions or assist respondents in structuring their answers to questions is a definite limitation of the technique". He further pointed out other weaknesses, "that self-completion questionnaires are unsuitable for asking open-ended questions of the type used particularly in attitude research". "Self-completion questionnaires cannot probe or ask the respondent to explain a particular answer, they cannot encourage the respondent to be less reticent or to give his own opinions and prejudices rather than slogans or cliches". "Where open-ended questions are included to allow respondents an opportunity to comment at length on a subject, the responses must be interpreted circumspectly than if interviewers had asked the same questions".

Offsetting these hazards on the other hand are a number of advantages - the most compelling being efficiency in data collection. The questionnaire survey process allows one, with relatively modest time and cost, to get information about a broad range of topics from a large number of respondents, and to do so with relatively little disturbance of the normal activities of the respondents. Brook [50] indicated advantages of questionnaire on cost grounds - "it normally costs no more than a third of what a comparable interview survey costs; alternatively, for the same cost, the sample size for a postal survey can be perhaps three times as large as that for a comparable interview survey". He went on - "a related advantage of postal surveys is that they can reach isolated areas and those members of the population whom interviewers find it difficult to catch at home; they remove the problems of sending interviewers to outlying areas" - "Postal surveys also allow respondents time to reflect on the questions (and possibly to look up records) so that they can give more considered and more precise answers". Handyside [143] also recognised that the two very obvious and undeniable advantages of questionnaires are that they are rapid and relatively inexpensive.

Smith [253] also indicated that the questionnaire survey is a good technique for exploration of attitudes, values, beliefs and motives.

Given these advantages and defects, the relative ease of standardisation and the relative efficiency of questionnaires dictated that this method is used as the primary technique for collecting information both at pretest and main data collection levels about individual perceptions and attitudes in this research study.

6.7 QUESTIONNAIRE DESIGN AND DEVELOPMENT EFFORT

A major initial strategic choice in selecting topical domains for an assessment questionnaire lies inn the ground rules for inclusion. One possible guideline is to formulate a coherent theoretical framework and then to concentrate the measurement effort on the essential conceptual components of that theory. The advantage to this approach is that of providing an explicit rationale and theoretical basis for inclusions and exclusions. On the other hand, it has the disadvantages of omitting measures deemed theoretically important by others.

The principle of question writing suggested by Kerlinger [175] was considered, described as follows:-

"1. Is the question related to the research problem and the research objectives?
2. Is the type of question right and appropriate?
3. Is the item clear and unambiguous?
4. Is the question a leading question?
5. Does the question demand knowledge and information that the respondent does not have?
6. Does the question demand personal or delicate material that the respondent may resist?
7. Is the question loaded with social desirability?"

Towards that end, an initial period of desk research to scan the existing literature and to identify information sources was carried out.

As a result a questionnaire was prepared in three main parts directed to intended respondents: building clients (housing associations); their consultant building designers; and main contractors engaged on site (see Appendix 2).

In order to overcome the problems indicated above by Kerlinger [173] and others (Hoinville [160], Leedy [186], Blalock Jr. and Blalock [32], Johnston and Pennypadier [169], Brook [50]):-

1. It was decided to distribute the questionnaires to the author's supervisors and to researchers and experts in the field of design and construction of building projects. Some useful comments were received.

2. The intended respondents were contacted and the questionnaire was tested in a pilot study (N = 25).

An overview of the comments received from the people contacted, and discussions held with author's supervisors indicated that the first set of questionnaires was discarded as inappropriate for data collection and subsequent analysis.

Other approach to data collection to be discussed in Chapter 7, was considered as the next line of action.

CHAPTER 7

MAJOR COMPONENTS OF THE RESEARCH INSTRUMENTS

7.0 MAJOR COMPONENTS OF THE RESEARCH INSTRUMENTS

7.1 INTRODUCTION

The intent of this chapter is to ascertain the strategic choice in selecting topical domains for the research instruments for the measurement of variables. The selection of scales and component questionnaire items raises many issues. A possible guideline is to scan the existing literature in search of constructs and questionnaire measurement operations that have some established evidence of empirical reliability, validity and utility, giving little regard for their places in some coherent theoretical framework. When an appropriate scale is not available, an effort was made in the construction of an entirely new scale, on a tentative basis, subject to further improvement.

The following goals were identified for the choice of the measuring instruments and develoment effort:

a) to provide a survey with topical coverage suited to the intended assessment and subsequent interpretation

b) to assure that the measuring instrument is suitable for use in a variety of construction project organisational contexts with respondents of diverse situations and characteristics

c) to achieve a satisfactory level of scale reliability and validity as far as possible

d) to assure that the scales are meaningful to the intended participants

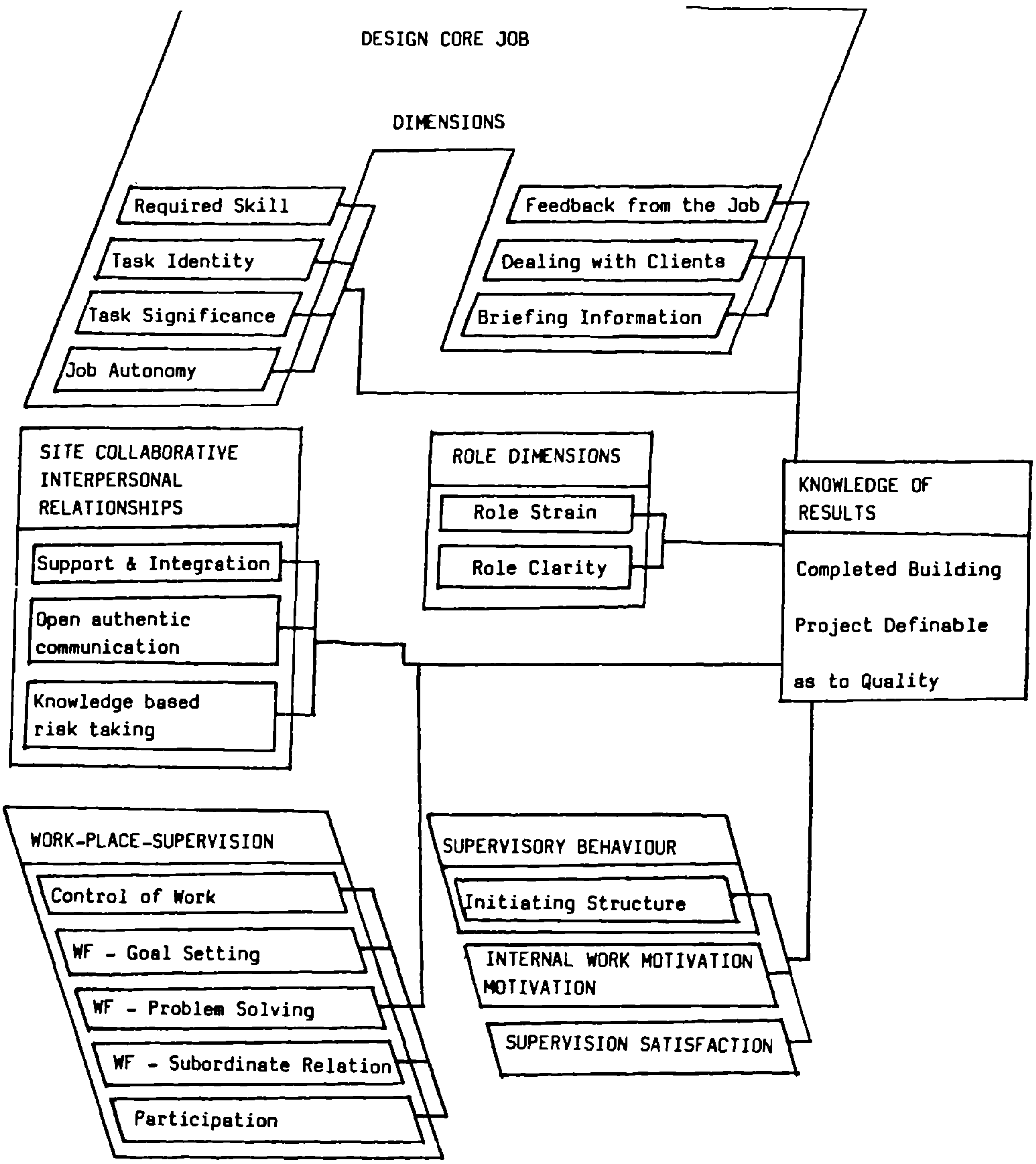
e) to keep the scales as short and as specific as possible, since it was discovered during the preliminary investigation that respondents often resist having questionnaires that take much of their time to administer.

Attempts will be made to satisfy the preceding criteria as far as possible.

An overview of the topical content of the questionnaire is displayed in Figure 16. Most of the scales have survived successive tests for field utility and for satisfactory statistical properties.

7.2 PRESENTATION AND CONCEPTUAL DEFINITION OF THE RESEARCH INSTRUMENTS

The measuring device operationalised in the research project is by sets of questionnaire documents: 'Building Design Questionnaire One', and 'Construction Site



NOTE: WF = Work Facilitation

Figure 16 Topical areas currently covered by scales in the Research Instruments

Questionnaire Two' divided into parts I to IV for site agents/managers, foremen category, site operatives and clerk of works respectively.

The research instruments are tabulated in Table 2 which could be easily located within the two main sets of questionnaire documents which will be administered for the purpose of data collection. The core questionnaire with departmental letter of introduction appear in Appendix 1 in their entirety.

The rest of the chapter will be devoted to each scale successively.

7.2.1 BUILDING DESIGN SETTING

Any measuring device is based on some underlying theory of 'what is considered important' regarding the phenomena under consideration. The theory which gave rise to the present instrument is based on earlier work by Hackman and Oldham [140], and by Hackman and Lawler [141]. The authors proposed the first five core job dimensions described below which have significant influence on employees' attitudes and behaviour and the work outcomes. These are named and conceptually defined as follows:

Table 2 Presentation of Research Instruments

SCALE/ SUBSCALE		LOCATION: BUILDING DESIGNER QUESTIONNAIRE ONE	CONSTRUCTION SITE QUESTIONNAIRE TWO, PART I	CONSTRUCTION SITE QUESTIONNAIRE TWO, PART II	CONSTRUCTION SITE QUESTIONNAIRE TWO, PART III	CONSTRUCTION SITE QUESTIONNAIRE TWO, PART IV
1.	DESIGN CORE JOB DIMENSIONS					
1.1	Required skill	Section B: items 4,7,11	-	-	-	-
1.2	Task Identity	Section B: items 3,9,15	-	-	-	-
1.3	Task Significance	Section B: items 5,13,17	-	-	-	-
1.4	Job Autonomy	Section B: items 2,14,18	-	-	-	-
1.5	Feedback from the Job	Section B: items 6,10,16	-	-	-	-
1.6	Dealing with Clients & Others	Section B: items 1,8,12	-	-	-	-
2.	Briefing Information	Section C: items 1 to 9	-	-	-	-
3.	Knowledge of Results	Section D: items 1 to 4	Section G: items 1 to 4	-	-	Section R: items 1 to 4
4.	SITE COLLABORATIVE INTERPERSONAL RELATIONSHIPS					
4.1	Problem solving through support & integration	-	Section F: items 1 to 6	-	-	-
4.2	Open, Authentic Communication	-	Section F: items 7 to 11	-	-	-
4.3	Knowledge-based risk taking	-	Section F: items 12 to 16	-	-	-
5.	Initiating Structure	-	-	Section I: items 1-10		

Table 2 continued

SCALE/ SUBSCALE		LOCATION				
		BUILDING DESIGNER QUESTIONNAIRE ONE	CONSTRUCTION SITE QUESTIONNAIRE TWO, PART I	CONSTRUCTION SITE QUESTIONNAIRE TWO, PART II	CONSTRUCTION SITE QUESTIONNAIRE TWO, PART III	CONSTRUCTION SITE QUESTIONNAIRE TWO, PART IV
6.	Internal Work Motivation	-	-	-	Section K: items 1-6	
7.	WORK-PLACE-SUPERVISION					
7.1	Control of Work	-	-	-	Section L: items 4 to 8	
7.2	WF - Goal setting	-	-	-	Section L: items 9 to 11	
7.3	WF - Problem Solving	-	-	-	Section L: items 12,13	
7.4	WF - Subordinate Relations	-	-	-	Section L: items 14 to 20	
7.5	Participation	-	-	-	Section L: items 21,22	
8.	Supervision Satisfaction	-	-	-	Section M: items 1 to 6	
9.	Role Strain	-	-	-	-	Section P: items 1 to 15
10.	Role Clarity	-	-	-	-	Section Q: items 1 to 4

WF = Work Facilitation

7.2.1.1 Required Skill Subscale

The skill variety measure comprises three items. It is designed to reflect the "degree to which a job requires a variety of different activities in carrying out the work, which involve the use of a number of different skills and talents of the individual".

7.2.1.2 Task Identity Subscale

The Task Identity measure is composed of three items. It is intended to tap "the degree to which the job requires completion of a whole and identifiable piece of work, i.e. doing a job from beginning to end with a visible outcome".

7.2.1.3 Task Significance Subscale

This subscale consists of three items and it is used to measure "the degree to which the job done by the individual has a substantial impact on the work of other people, whether in the immediate organisation or in the external environment, e.g. construction job site".

7.2.1.4 Job Autonomy Subscale

Similarly, this subscale consists of three items and it is intended to measure "the degree to which the job provides substantial freedom, independence and discretion to the individual in scheduling the work and in determining the procedures to be used in carrying it out".

7.2.1.5 Feedback from the Job Subscale

This subscale is composed of three items, and it is intended to tap "the degree to which carrying out the work activities required by the job results in the individual obtaining direct and clear information about the effectiveness of his or her performance".

In addition to the above for subscales, a measure was obtained for a supplementary dimension which has been found to be 'helpful' in understanding job and individual reactions to it [140]. It is described below.

7.2.1.6 Dealing with Client and Others Subscale

The subscale comprises three items, and it is intended to measure "the degree to which the job requires the individual to work closely with other people in carrying out the work activities including dealing with building clients and other organisation members, e.g. quantity surveyors, services engineers, structural engineers, etc."

7.2.1.7 Motivating Potential Score (MPS)

Following the above theoretical conceptions, it was proposed [140] that a summary score reflecting the overall MPS of a job in terms of the core job dimensions could be generated. That is, it is possible to combine the score of a job on the five dimensions described above into a single index. This index called MPS, "reflects the overall potential of the job to prompt internal work motivation on the part of job incumbent". The score is computed as follows:

$$\text{MPS} = \left[\frac{\text{Required Skill} + \text{Task Identity} + \text{Task Significance}}{3}\right]$$

$$\times\ (\text{Job Autonomy}) \times (\text{Feedback})$$

As can be seen from the formula, an increase in any of the core dimensions will increase the MPS; but (because of the multiplicative relationship among its components) if any of the three major components of MPS is low, the resulting MPS also would be low.

7.2.1.8 Briefing Information Scale

The briefing information scale has been designed by the author, on a tentative basis, regarding requirements for the building project, and it is to reflect "the degree to which the client's statements are implicit or explicit of the type of materials and products and their specification and the standards they should conform to".

7.2.2 ON-SITE MANAGEMENT AND ORGANISATIONAL SETTING

The following section concerns the research instruments used to collect individual-level information from site management and site operative cohorts.

7.2.2.1 Collaborative Interpersonal Relationships Scale

A major theme in the study of organisations has been interpersonal relationships: the relationship between the individual and the organisation, Argyris [10,11], McGregor [205], and participatory management, Likert [191], Leavitt [189].

One aspect of such studies is the view that organisations constrain the psychological growth of the individual and as such his contributions to the achievement of the goals of the organisation in a given situation. This view often leads to a concern expressed for creating conducive environment at site level. Practical research by BRE [21] has indicated that "...quality at site level depends on the ability of site staff to create an environment where good work could and was likely to take place. Sites with acceptable quality standards tended to be characterised by a 'consultative' approach to problem-solving - anyone on site could raise questions and many individuals could contribute to solution..."

An effort was therefore made to measure this important aspect of work at site level.

The Collaborative Interpersonal Relationships scale was adopted from Aram et al [8] and conceptually defined as "the degree of team collaboration, agreement on goals, self-control, mutual exchange, confidence and trust among members". The scale is divided into three subscales used in this study, and each subscale will be described below.

7.2.2.1.1 Problem-solving through support and integration subscale

The subscale consists of six items and designed to reflect "the extent to which co-operation exists among site staff in carrying out their group or individual tasks, and consultative-approach to solving quality-related problems in site work".

7.2.2.1.2 Open authentic communication subscale

This subscale comprises four items, and is defined as "acts which increase the understanding and knowledge about what is going on in a group of workers and enhance the freedom for members to raise questions and many individuals could contribute to solutions".

7.2.2.1.3 Knowledge-based risk-taking subscale

This subscale is composed of five items, designed to reflect "the extent of prevailing acts which tend to value expertise rather than status or position in solving technical innovation and other quality-related problems in site work".

7.2.2.2 Supervisory Initiating Structure Scale

This measure is comprised of ten items adopted from Stogdill's [260] Leader Behaviour Descriptive Questionnaire Form XII (cf. Cook et al [86]). The scale has been designed to mirror the "degree to which the supervisor is likely to initiate psychological structure for subordinates by doing such things as assigning particular tasks, specifying procedures to be followed, clarifying his expectations of subordinates and scheduling work to be done" (House & Mitchell [161], p.321).

The scale was originally designed to tap subordinates' view of leadership behaviour, it is adopted in this research for direct administration to site supervisory personnel to measure their supervisory/managerial behaviour.

The scale was used in many research studies, and internal reliability evidence has been reported by Cook et al [86] for the original subscale.

7.2.2.3 Internal Work Motivation Scale

Internal work motivation is to be measured using an adapted scale from Hackman and Oldham [140] and the scale consists of six items. The scale is intended to tap "the degree to which the individual is self-motivated to perform effectively and refers to the extent to which the individual experiences positive feelings when doing well and negative reactions when working poorly".

The scale has been applied in many research settings and evidence of internal reliability has been reported by Cook et al [86].

7.2.2.4 Work-Place-Supervision Scale

In most construction sites a subordinate's immediate supervisor is singularly important in determining the subordinate's work environment, and under some circumstances can have significant impact upon work performance. The effect of leadership has been studied extensively from many different perspectives (Feidler [123], Mintzberg [207], Stogdill [260]).

The approach in this section of the study is one of asking subordinates descriptive questions about a supervisor's style regarding work-place-supervision on subordinate's daily tasks basis.

The scale is an adaptation from Cammann et al [62] and is divided into the following five subscales:-

7.2.2.4.1 Control of work subscale

This subscale comprises five items and it is designed to tap "the extent to which the supervisor maintains control of work that is being done by knowing the state of project, current achievement of quality of work, planning work flows and make sure the work is being done correctly".

7.2.2.4.2 Work facilitation - goal setting subscale

The above subscale has three items operationalised to tap "the extent to which the supervisor helps the subordinates to have clear project quality requirements and integrated goals so that they can know what they should be doing".

7.2.2.4.3 Work facilitation - problem solving subscale

This subscale has two items and is designed to measure the "extent to which the supervisor helps subordinates solve work-related problems and their discovery before they get out of hand".

7.2.2.4.4 Work facilitation - subordinate relations subscale

The above subscale has seven items, designed to measure "the extent to which the supervisor maintains good communication, helpful and equitable relations with subordinates in carrying out their work on site".

7.2.2.4.5 Participation subscale

The participation subscale has two items and is designed to measure "the extent to which the supervisor encourages subordinates to participate in decisions pertaining to their work".

7.2.2.5 Supervision Satisfaction Scale

This scale is an adaptation from Smith's [253] Index of Organisational Reactions and is composed of six items. The scale is designed to tap "the degree to which the operative is satisfied with the kind of supervision he receives and results from a balancing and summation of many specific likes and dislikes experienced in connection with work supervision".

7.2.2.6 Role Dimension Scale

The role played by the clerk of works in the achievement of quality in construction on the job site has been cited on many occasions. Bentley [21], Freeman and Bentley [127], NEDO [219], Newlove [221], Fern [122], Black [33], Woodhouse [291], Pickavance [232], Burnell [59], Vivian [271], Johnstone [170] expressed the opinion that the clerk of works is responsible for and limited to duties of inspection which are not defined, but which must be less than those otherwise associated with his work.

When it comes to quality control, the clerk of works is an invaluable member of the building team.

In this study it was decided to investigate the role dimension, as played by the clerk of works in the achievement of quality in site construction work. Two scales were adapted to measure this dimension and are described as follows:

7.2.2.6.1 Role strain scale

This scale has fifteen items adapted from Kahn et al [171] designed to reflect "the extent to which the individual encounters difficulty in getting sufficient authority and information to carry out his job and in meeting his role expectations".

The scale has been used in many research settings and internal reliability evidence has been reported by Cook et al [86].

7.2.2.6.2 Role clarity scale

This scale is an adaption from Berkowitz [23] and consists four items designed to measure "the degree to which individual understands what his duties are, relationship with others, the existence of guides, directives, policies and how he is evaluated".

The scale has been used in other research settings and construct validation and internal reliability evidence have been reported by Cook et al [86] in many research programmes.

7.3 KNOWLEDGE OF RESULTS - "QUALITY MEASURE INDEX"

Measure of quality presents an extraordinary problem arising from the uniqueness of 'required quality' in many and different construction project situations and the idiosyncrasies of definition, categorisation and measurement.

Since quality is now so central to the assessment of construction projects in many circumstances and has positive benefits for both the construction industry and its clients ("the principal benefit to the client from having a building that conforms to his specifications are likely to include lower costs of rectifying defects and reduced risk of operating costs in excess of those budgeted for" - "for the construction industry it should mean lower costs of rectification and thus more efficient use of resources"), a major effort was undertaken to incorporate quality measurement into this methodology.

Quality is best regarded as a family of measures comprising a set of work outputs with a set of work inputs along with intervening process indicators or activity measures.

Atkinson [13] has defined this family of measures in the following ways:

1. Quality of the design process - including reliability of the initial brief; reliability of the design solution and of the detailed specification; reliability of the information that has been used as the basis for the design, and the selection of products; reliability of the calculations relating quality to cost.

2. Quality of the construction process - the reliability of the organisation, procedures and skills of the builder to interpret the design and provide the end

product on the site in accordance with the design specification.

3. Quality of of the products - the reliability of all the materials/products/components supplied to the builder for incorporating in the building.

4. Quality of maintenance - the reliability of the maintenance programme that the building use is not altered in a way that will affect its performance.

It is not the intention here to assess all the family of measures described above, however, an attempt is made to evaluate the current state of the project under construction.

A complete assessment of construction project's existing state requires an evaluation that reflects the criteria of all interested parties. As participants and observers, the members in the construction project almost always quality as relevant interested parties, it is essential that assessors have some methods to describe the way they view the state of the project.

To that end an attempt was made to adapt "Knowledge of Results scale" from Hackman and Oldham [140] as a measure of quality. This instrument is conceptually defined as "the degree to which the individual knows and understands on a continuous basis how effectively the construction of the project is being performed or carried out". The scale has four items and construct validity and internal reliability evidence have been reported by Hackman and Oldham [140], Oldham et al [224], Kiggundu [178].

Majority of the scales described in this chapter were standardised scales and were used in many other research programmes. The empirical properties of the scales are described in Chapter 8. Statistical properties of the scales reported in previous research settings are tabulated in Table 4 for easy comparison with the findings in Table 3 and Table 11 in this study (see Chapter 8).

CHAPTER 8

EMPIRICAL PROPERTIES OF THE RESEARCH INSTRUMENTS

8.0 EMPIRICAL PROPERTIES OF THE RESEARCH INSTRUMENTS

8.1 INTRODUCTION

The complex issue of measurement in theoretical and applied research settings, concern the process of linking abstract concepts to empirical indicators.

Abstract concepts such as self-esteem, interpersonal relationships, internal work motivation and so on are among the most salient and substantively infused elements used in the explanation of social behaviour. As Zeller and Carmines [293] pointed out, abstract concepts can only be approximated by empirical indicators. It is indeed the very vagueness, complexity and suggestiveness of concepts that allow them to be empirically referenced with varying degrees of success at different times and places.

The fundamental openness of meaning that is characteristic of concepts has been described by Kaplan [172]. He notes that concepts can never be thought of as closed, fixed quantities. Rather, the specification of the meaning of concepts always leaves their usage uncertain to some degree. He further points out that "as the theory is used for - scientific as well as practical purposes - its meaning is progressively more fixed; but some degree of openness always remains".

Indicators, on the other hand, are intended to approximate and locate concepts empirically. But it should be noted that indicators are never able to fully exhaust nor completely duplicate the meaning of theoretical concepts. Any particular set of empirical indicators, therefore, is only a small subset of an almost infinite number of possible indicators that could be selected to represent a particular concept.

Within the field of empirical measurements two key terms, reliability and validity, provide the essential language of measurement. The importance of these two key terms has been stressed in the literature concerning measuring instruments, Zeller and Carmines [293], Nunnally [223], Anastasi [6] and Carmines & Zeller [65].

At the most general level, these are the two basic properties of empirical measurements [65].

In the light of the above, an attempt was made in this chapter to determine the psychrometric properties of the research instruments presented in Table 2 for both preliminary investigation and main data collection.

Before describing the two terms in detail, it is worthwhile to sound a word of warning: While reliability and validity are desirable within research setting of social scientific type, the measurement of any phenomenon within such setting, always contains a certain amount of chance error. The goal of error-free measurement - while laudible - is never attained in any area of scientific investigation [293]. Instead, as Carmines and Zeller [65] have observed, "the amount of chance error may be large or small, but it is universally present to some extent; two sets of measurements of the same features of the same individual will never exactly duplicate each other".

8.2 RELIABILITY

A rather common definition of reliability is provided by Nunnally [223]: "Reliability concerns the extent to which measurements are repeatable - by the same individual using different measures of the same attribute or by different persons using the same measure of an attribute".

A highly reliable measure of a certain variable would imply, for example, that researchers using the same indicators to measure that variable - whether they be self-ratings, observer ratings, or whatever - would obtain the same results for a given set of individuals [293]. Conversely, an unreliable measure is one that does not provide repeatable or consistent results. Thus, reliability is inversely related to the amount of random error in the measuring process [293].

8.2.1 ASSESSING RELIABILITY

There are four basic methods for estimating the reliability of empirical measurements - these are "the retest method; the alternative-form method; the split-halves method, and the internal consistency method [65].

Each method will be discussed and an evaluation will be made of its strengths and weaknesses and the way it is related to this research study.

8.2.1.1 Retest Method

This method involves the situation whereby the same test is given to the same group of people after a period of time. One then obtains the correlation between scores on the two administrations of the same test. If one obtains exactly the same results on the two administrations of the test, then the retest reliability coefficient will be 1.00. But, invariably, the correlation of measurements across time will be less than perfect.

While test-retest correlations represent simple and an intuitively appealing procedure by which to assess reliability, the technique has its inherent impracticality in that two administrations of the measure to the same respondents are needed. The foregoing is extremely difficult to satisfy in this research on the grounds that the chance of getting two co-operations from the intended participants in the research is very remote indeed. To secure one co-operation is difficult enough never mind two. Moreover, site personnel especially site operatives do change with time which means there is no assurance that the respondents will remain the same at the second administration. Lastly, a significant weakness of this procedure is 'memory effect': experience gained in filling in the measure the first time may unduly introduce a bias the second time around especially when the time interval is relatively short. Memory effects lead to inflated reliability estimates [65]. In fact, Nunnally [223] believes that "during the two-week's to one-month's time in which it is advisable to complete both testings, memory is likely to be a strong factor, in that, the person's memory of his responses during the first test is quite likely to influence the responses which he gives in the second test. Hence, retest method will not be taken up here.

8.2.1.2 Alternative-Form Method

The procedure involved in this method is that of administering an alternative form of the same test on two occasions. The correlation between the alternative forms provides the estimate of reliability. It is recommended that the two forms be administered about two weeks apart, thus allowing for day-to-day fluctuations in the person to occur [223]. Apart from associated with the practical limitations of test-retest procedure mentioned previously, this procedure has the unique difficulty of having to devise or use two equivalent versions of the same measure with the elements of parallel measurements (i.e. identical means, variances and inter-correlations) to satisfy. A task extremely difficult to achieve in this research, if not in all cases. The resources available to the author do not allow search for alternative form of measures for use in the present research. Given the circumstances, the decision is to drop this procedure.

8.2.1.3 Split-Halves Method

Split-halves procedure concerns the partitioning of a measure into two halves for administration simultaneously. The correlation between the two halves is the reliability estimate. Partitioning may be achieved by splitting component items into even-numbered and odd-numbered groups or using random selection method [65]. Unfortunately, a problem characteristic of this procedure is the lack of consistency of reliability estimate generated by different splits even though the same component items are involved [293]. The latter is good enough reason to reject this procedure.

8.2.1.4 Internal Consistency Method

The last evaluation technique for reliability is known as the internal consistency procedure. The technique involves an assessment of the homogeneity of the component items in a test. The important merits of this procedure lie in its single administration of the measure and no extra effort on partitioning of the component items required; neither repeating of items in a test. The foregoing is the prime reason for its employment in this research.

By far the most popular of the reliability estimates employed in this method is by Cronbach's Alpha and Kuder-Richardson 20 formula, represented: KR-20. Cronbach's alpha is used for polychotomous items while KR-20 is used to determine the reliability of scales composed of dichotomously scored items (items scored one or zero depending on whether the respondent does or does not possess the particular characteristic under investigation).

In order to generate a summary statistic indicative of internal consistency reliability, a well accepted Cronbach's Alpha procedure as noted in the literature (e.g. Nunnally [223], Carmines and Zeller [65], Anastasi [6], Gilford [132], Zeller and Carmines [293]) will be employed in computations as discussed in the following section and at a later stage in the thesis.

8.2.1.4.1 Internal consistency reliability for preliminary data

The internal consistency method was utilised in the assessment of reliability coefficients of the research instruments at pretest level. The coefficients were statistically computed using the subprogram 'Reliability' from SPSS update 7-9 [162]. The default MODEL=ALPHA with listwise deletion of missing values in the subprogram was chosen.

Table 3 presents means, standard deviations and internal consistency reliability coefficients (Cronbach's Alpha Coefficients) so computed for each of the instruments.

In view of the absence of a rigid rule governing the magnitude of a reliability coefficient as acceptable, the nature and purpose of the research may serve as a

Table 3 Means, Standard Deviations and Internal Consistency Reliability Coefficients of Research Instruments Using Preliminary Data

SCALE/SUBSCALE		MEAN	STANDARD DEVIATION	INTERNAL CONSISTENCY RELIABILITY (CRONBACH'S ALPHA COEFFICIENT)
1.	Hackman & Oldham's [140] Core Job Characteristics			
1.1	Required Skill	3.72	1.05	0.55 (n=20)
1.2	Task Identity	5.57	1.75	0.69 (n=20)
1.3	Task Significance	5.98	1.27	0.50 (n=20)
1.4	Job Autonomy	5.13	1.33	0.67 (n=20)
1.5	Feedback from Job	5.92	1.05	0.68 (n=20)
1.6	Dealing with Clients & Others	5.45	1.01	0.60 (n=20)
1.7	Motivating Potential Score (MPS)	162.79	56.65	
2.	Briefing Information	24.80	7.73	0.82 (n=20)
3.	Knowledge of Results (Hackman & Oldham's [140])	5.47	1.14	0.77 (n=20)
4.	Site Collaborative Interpersonal Relationships (Aram et al [8])			
4.1	Problem Solving through Support & Integration	4.07	0.80	0.65 (n=20)
4.2	Open, Authentic Communication	3.83	0.73	0.63 (n=20)
4.3	Knowledge-based risk taking	3.18	0.46	0.51 (n=20)
5.	Initiating Structure (Stogdill's [260])	40.85	6.40	0.61 (n=20)
6.	Internal Work Motivation (Hackman & Oldham [140])	5.49	1.02	0.70 (n=20)

Table 3 (continued)

SCALE/SUBSCALE		MEAN	STANDARD DEVIATION	INTERNAL CONSISTENCY RELIABILITY (CRONBACH'S ALPHA COEFFICIENT)
7.	Work-Place-Supervision (Cammann et al [62])			
7.1	Control of Work	5.62	0.96	0.86 (n=20)
7.2	WF - Goal Setting	5.77	0.75	0.50 (n=20)
7.3	WF - Problem Solving	5.73	0.68	0.73 (n=20)
7.4	WF - Subordinate Relations	5.34	0.94	0.67 (n=20)
7.5	Participation	5.13	1.21	0.56 (n=20)
8.	Supervision Satisfaction (Smith's [253])	3.69	0.74	0.56 (n=20)
9.	Role Strain (Kahn et al [171])	2.44	0.97	0.87 (n=20)
10.	Role Clarity (Berkowitz [23])	4.30	1.68	0.89 (n=20)

WF = Work Facilitation
n = number of cases

decisive criteria for the interpretation of reliability coefficients.

Nunnally [223] has suggested that reliability of 0.50 magnitude is satisfactory for an exploratory research instrument. The present research instruments are incidentally explanatory in nature. Looking at Table 3 all the Cronbach's Alpha have satisfied the 0.50 magnitude.

In summary, the research instruments at pretest level, therefore, have satisfactory internal consistency reliability.

8.3 VALIDITY

An important step, after a measuring instrument has been chosen, is to find out whether or not it is useful. Nunnally [223] has asserted that: "in a very general sense, a measuring instrument is valid if it does what it is intended to do". Consequently, if a set of indicators were perfectly valid, it would represent the intended - and only the intended - concept. While reliability is empirical in essence, validity, on the other hand, is theory grounded. It deals with the linkage between an abstract concept and its empirical indicator.

A less than perfectly valid measure, would imply that it does not fully represent the concept or that it represents something other than the concept. Thus, to have a valid measure, one must have a reliable one; but simply because one has a reliable measure does not mean that it is valid as well. Reliability, then, becomes a necessary but not sufficient condition for validity [293].

In this section, the three main categories of the validation procedures [65] will be discussed and like reliability, the suitability of each validation procedure will be reviewed. These are: content validity, criterion-related validity and construct validity.

8.3.1 CONTENT VALIDITY

Content validity involves essentially the systematic examination of the test content to determine whether it covers a representative sample of the behaviour domain to be measured [6]. Content means the theoretical substance constituting the concept. Precise assessment of content validity of a measure is exceedingly difficult especially when the concept involved is theoretically abstract and lacking a consensus on its content.

In the absence of well-defined, objective criteria, Nunnally [223] has noted: "Inevitably content validity rests mainly on appeals to reason regarding the adequacy with which important content has been sampled and on the adequacy with which the content has been cast in the form of test items".

It is difficult to think of any abstract theoretical concept in this research for which there is an agreed upon domain of content relevant to the phenomenon under investigation. In other words, there is no agreed upon criteria for determining the extent to which any measure in this research has attained content validity. It appears content validation is relatively an imprecise process based on subjective judgement. The absence of rigour in such a process has engendered a call in the literature to abandon it (cf. Carmines and Zeller [65]). Hence content validation will not be pursued here.

8.3.2 CRITERION-RELATED VALIDITY

Criterion-related validity concerns correlating a measure with some theoretically pertinent external criterion. For instance, 'A'-level examinations are considered a valid predictor if they are able to forecast university success well. A high correlation between 'A'-level examinations and eventual university success is an indicator of high criterion-related validity and vice-versa. In the words of Nunnally

[223], criterion-related validity "is at issue when the purpose is to use an instrument to establish some important form of behaviour that is external to the measuring instrument itself, the latter being referred to as the criterion". A prerequisite for undertaking such validation is, of course, the existence of some relevant criterion.

Considering the above requirement, there is no relevant external criteria against which any measure in this research can be reasonably evaluated. It is clear that the more abstract the concept, the less likely one is to discover an appropriate criterion for assessing a measure of it. The use of this validation procedure has not been popular in the literature. As noted by Zeller and Carmines [293], the criterion related validity of measures typical of the social sciences is simply inapplicable to many abstracts, due to the absence of any relevant external criteria against which to evaluate measures.

The above limitations have prevented criterion-related validity to be pursued in this research.

8.3.3 CONSTRUCT VALIDITY

The construct validity of a test is the extent to which the test may be said to measure a theoretical construct or trait [6].

Construct validity must be investigated whenever no criterion or universe of content is accepted as entirely adequate to define the quality to be measured [293].

In formulating the underlying logic of construct validation: "construct valuation takes place when an investigator believes his instrument reflects a particular construct, to which are attached certain meanings. The proposed interpretation generates specific testable hypotheses, which are a means of confirming or disconfirming the claim" [65].

The construct validity of a measure would be justified if subsequent analysis revealed numerous successful predictions involving diverse theoretically related variables. Thus, construct validity is not established by confirming a single prediction on different occasions or confirming many predictions in a single study. Instead, construct validation, as noted in the literature (e.g. Zeller and Carmines [293], Anastasi [6], Nunnally [223], Carmines and

Zeller [65], Gilford [132]) ideally requires a pattern of consistent findings involving different researchers across a significant portion of time and with regard to a variety of diverse but theoretically relevant variables.

Regarding the present study, all the scales within the research instruments were selected from standardised questionnaires that have established evidence of empirical reliability and construct validity, with one exception. The latter refers to Briefing Information scale which was designed to measure "the degree to which the client's statement regarding project requirements are implicit or explicit of the type of materials and products and their specification and the standard they should conform to". Construct validation will therefore be taken up here.

Tabulation of prevalidated scales for construct validation purposes is presented in Table 4. The table presents statistical properties of the scales reported in previous research settings. Looking at the table it could be noted that all the scales were employed in other research settings across a significant portion of time and have established evidence of empirical reliability, validity and utility.

Table 4 Presentation of Prevalidated Scales for Construct Validation Purposes (X = mean, SD = Standard Deviation, IR = Internal Consistency Reliability Coefficient, and N = Number of cases)

	SCALE/SUBSCALE	Utilisation of the Scale/Subscale in Previous Research Settings (see refs)														
		Hackman and Oldham [140] (N=658)			Oldham et al [224] (N=6930)			Dunham [110] (N=784)			Bhagat and Chassie [31] (N=65)			Evans et al [117] (N=343)		
		X	SD	IR	X	SD	IR	X	SD	IR	X	SD	IR	X	SD	IR
1.	Hackman & Oldham's Core Job Characteristics															
1.1	Required Skill	4.49	1.67	0.71	4.53	1.57	0.68	-	-	0.76	-	-	0.68	-	-	0.53
1.2	Task Identity	4.87	1.43	0.59	4.65	1.44	0.61	-	-	0.72	-	-	0.78	-	-	0.52
1.3	Task Significance	5.49	1.29	0.66	5.49	1.25	0.58	-	-	0.72	-	-	0.72	-	-	0.50
1.4	Job Autonomy	4.80	1.43	0.66	4.78	1.39	0.64	-	-	0.73	-	-	0.66	-	-	0.53
1.5	Feedback from Job	4.98	1.41	0.71	4.81	1.34	0.68	-	-	0.75	-	-	0.73	-	-	0.38
1.6	Dealing with Clients & Others	5.29	1.34	0.59	5.46	1.31	0.62	-	-	-	-	-	-	-	-	0.51
1.7	Motivating Potential Score (MPS)	128.31	72.73	-	122.10	69.41	-	-	-	-	-	-	-	-	-	-
								Kiggundu [178] (N=138)								
2.	Hackman and Oldham's Knowledge of Results	5.18	1.09	0.76	5.04	1.14	0.71	5.32	1.02	-	-	-	-	-	-	-

Table 4 (continued)

	SCALE/SUBSCALE	Utilisation of the Scale/Subscale in Previous Research Settings (see refs)														
		Aram et al [8] (N=110)			Stogdill [260] (N=235)			Stogdill [261] (N=55)			Hackman and Oldham [140] (N=658)			Wall et al [277] (N=47)		
		X	SD	IR	X	SD	IR	X	SD	IR	X	SD	IR	X	SD	IR
3.	Aram et al's Collaborative Inter-Personal Relationships															
3.1	Problem Solving through Support & Integration	-	-	0.87	-	-	-	-	-	-	-	-	-	-	-	-
3.2	Open, Authentic Communication	-	-	0.80	-	-	-	-	-	-	-	-	-	-	-	-
3.3	Knowledge-based risk taking	-	-	0.80	-	-	-	-	-	-	-	-	-	-	-	-
4.	Stogdill's Initiating Structure	-	-	-	38.6	5.7	0.79	38.5	5.0	0.77	-	-	-	-	-	-
5.	Hackman and Oldham's Internal Work Motivation	Oldham et al [224] (N=6930)			Hackman and Lawler [141] (N=201)			Hackman and Lawler [142] (N=136)								
		5.50	0.89	0.69	5.18	1.02	0.71	5.51	0.87	0.71	5.39	0.96	0.75	4.78	0.81	0.58
6.	Kahn et al's Role Strain	Sheridan and Vredenburgh [249] (N=216)			Eden and Jacobson [113] (N=179)											
		2.35	0.60	0.87	-	-	0.84	-	-	-	-	-	-	-	-	-
7.	Berkowitz's Role Clarity	Lyons [195] (N=133)			Ivancevich [167] (N=86)			Cammann et al [62] (N=400)								
		-	-	0.70	-	-	0.76	-	-	0.53	-	-	-	-	-	-

Table 4 (continued)

SCALE/SUBSCALE		Utilisation of the Scale/Subscale in Previous Research Settings (see refs)											
		Cammann et al [62] (N=400)			Smith et al [254] (N=23,409)			Dunham & Herman [112] (N=12,971)			Dunham [111] (N=3,610)		
		X	SD	IR	X	SD	IR	X	SD	IR	X	SD	IR
8.	Cammann et al's Work-Place-Supervision												
8.1	Control of Work	-	-	0.87	-	-	-	-	-	-	-	-	-
8.2	WF - Goal Setting	-	-	0.82	-	-	-	-	-	-	-	-	-
8.3	WF - Problem Solving	-	-	0.83	-	-	-	-	-	-	-	-	-
8.4	WF - Subordinate Relations	-	-	0.93	-	-	-	-	-	-	-	-	-
8.5	Participation	-	-	0.76	-	-	-	-	-	-	-	-	-
9.	Smith's Supervision Satisfaction	-	-	-	3.34	-	-	-	-	0.90	-	-	0.88

WF = Work Facilitation

Comparing the statistical entries of Table 3 (pretest data in this study) with that of Table 4 (pre-validated scales) it will be noted that the means, standard deviations and the reliability coefficients are considerably similar. Quite a number of the reliability coefficients reported in Table 3 have high magnitude. It can be concluded that the scales at pretest level performed satisfactorily.

8.3.3.1 Item Analysis Using Preliminary Investigation Data

As indicated earlier, the briefing information scale was newly designed, an effort was therefore made to assess the construct validity of the scale at pretest level.

Nunnally [223] has indicated that, the way to test the adequacy of the outline of a domain relating to a construct is to determine how well the measures of items "go together" in empirical investigations. He pointed out that in studies of individual differences, the first step is to obtain scores for a sample of individuals on the items, next, each item is correlated with all other items. An analysis of the resulting correlation provides evidence about the extent to which all the measures tend to measure the same thing.

Following the suggestions outlined above by Nunnally [223], measures of the items were obtained from 20 respondents and a correlation matrix using subprogram 'FACTOR' in SPSSX [257] of the 9 items used to measure the briefing information is presented in Table 5. On the whole, the items intercorrelate positively, consistently and significantly. The result of the investigation as shown in the table would lead to the following conclusion: if all the proposed measures correlate highly with one another, it can be concluded that all measure much the same thing [223].

Table 5 Correlation Matrix of Briefing Information Items Using Preliminary Investigation Data

Items	1	2	3	4	5	6	7	8	9
1	-								
2	.791	-							
3	.741	.771	-						
4	.254*	.511**	.292*	-					
5	.584	.582	.348*	.461**	-				
6	.519**	.660	.774	.307	.475**	-			
7	.535	.622	.747	.281*	.524**	.665	-		
8	.526**	.615	.458*	.078	.487**	.588	.651	-	
9	.010	.053	.041	.104*	.144*	.256*	.132*	.049	-

* p < .005, ** p > .005, p > .001

Looking at the above table, only item number 9 correlates relatively less with the rest of the items. It correlates positively only with four of the items in the scale as a whole.

It should be recalled from Table 3 that the briefing information scale has an internal reliability coefficient of 0.82 (n=20) magnitude. The detail of item total statistics is shown in Table 6 was obtained using subprogram 'RELIABILITY' in SPSSX [257].

Taking this, and the correlation coefficients among the items into account, it can be deduced that the scale measures what it has been designed to measure.

8.4 GOODNESS OF FIT TEST USING PRELIMINARY INVESTIGATION DATA

In this section we shall discuss the application of one of the available non-parametric statistics to this research methodology. Non-parametric statistics make no assumptions regarding the shape of population distributions.

The statistical test that was chosen here is 'The Kolmogrov-Smirnov Goodness of Fit Test'. The test is in this instance essentially concerned with the agreement between the distribution of a set of sample values and a theoretical distribution. That is, the routine tests

Table 6 Item-Total Statistics for Briefing Information Scale Using Preliminary Investigation Data

ITEM	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
1	21.8000	24.1684	.7109	.8546	.8250
2	21.7000	23.2737	.8398	.8535	.8152
3	21.9500	24.7868	.7498	.9533	.8200
4	21.8000	27.4316	.3878	.5182	.7151
5	22.2500	24.0921	.6386	.7541	.8350
6	22.3500	23.0861	.7638	.8683	.8389
7	22.5000	22.4737	.7537	.8547	.8400
8	22.4500	24.2605	.6280	.7989	.8355
9	21.6000	29.5158	.1197	.4447	.8415
Cronbach's alpha coefficient = 0.82					

whether the observed data in this research could reasonably have come from a theoretical distribution specified in the study.

The method involved was that the cumulative distribution functions for the observed data and the theoretical distribution are computed, as well as the maximum difference between them. The Kolmogrov-Smirnov (K-S) Z is determined from the large difference (positive or negative). The larger the value of Z, the less likely it is that the observed and theoretical distributions are the same [162]. To that effect, the values were statistically computed using the subprogram 'K-S(NORMAL)' from SPSSX [257]. Table 7 presents most extreme differences and K-S Z values; whereby the two-sided K-S test for goodness of fit was used for the preliminary investigation data. From Table B (in the Appendix) the critical region of significance level of size alpha = 0.02 corresponds to the value of 0.329 of .98 quantile. Since all the values of absolute differences for the scales presented in Table 7 are less than 0.329, the null hypothesis is accepted, that is, the observed data in this research have reasonably come from a theoretical distribution of the population specified in the study. Moreover, all the values of K-S Z shown in Table 7 are less than the maximum tabulated by Smirnov [255], i.e. they are within the acceptable limits.

Table 7 Kolmogrov-Smirnov (K-S) Goodness of Fit Test (Normal) Using Preliminary Investigation Data

SCALE/SUBSCALE		MOST EXTREME DIFFERENCES			K-S Z
		Absolute	Positive	Negative	
1.	Design Core Job Dimensions				
1.1	Required Skill	0.185	0.185	-0.096	0.826
1.2	Task Identify	0.204	0.155	-0.204	0.888
1.3	Task Significance	0.208	0.149	-0.208	0.930
1.4	Autonomy	0.213	0.213	-0.201	0.953
1.5	Feedback from the Job	0.150	0.150	-0.149	0.673
1.6	Dealing with Client	0.291	0.243	-0.291	1.303
2.	Briefing Information	0.157	0.157	-0.143	0.703
3.	Knowledge of Results	0.139	0.107	-0.139	0.622
4.	Site Collaborative Interpersonal Relationships				
4.1	Problem Solving through Support and Integration	0.147	0.125	-0.147	0.655
4.2	Open, Authentic Communication	0.179	0.179	-0.165	0.800
4.3	Knowledge-based risk taking	0.183	0.183	-0.176	0.818
5.	Initiating Structure	0.147	0.140	-0.147	0.657
6.	Internal Work Motivation	0.091	0.091	-0.074	0.408
7.	Work-Place-Supervision				
7.1	Control of Work	0.242	0.122	-0.242	1.084
7.2	WF - Goal Setting	0.232	0.195	-0.232	1.037
7.3	WF - Problem Solving	0.328	0.272	-0.232	1.466
7.4	WF - Subordinate Relations	0.121	0.084	-0.121	0.540
7.5	Participation	0.203	0.155	-0.203	0.909
8.	Supervision Satisfaction	0.145	0.108	-0.145	0.631

Table 7 (continued)

SCALE/SUBSCALE		MOST EXTREME DIFFERENCES			K-S Z
		Absolute	Positive	Negative	
9.	Role Strain	0.228	0.173	-0.228	1.021
10.	Role Clarity	0.115	0.099	-0.115	0.515

n = 20

WF = Work Facilitation

Probably the most widely used non-parametric test of 'goodness of fit' is the chi-square test - χ^2. The K-S test was chosen in this study in preference to χ^2 because of the following reasons [251]:

(i) the K-S one-sample test treats individual observations separately and thus, unlike the χ^2 test for one sample, need not lose information through the combination of categories;

(ii) when samples are small, and therefore adjacent categories must be combined before χ^2 may properly be computed, the χ^2 test is definitely less powerful than the K-S test;

(iii) moreover, for very small samples the χ^2 test is not applicable at all, but the K-S test is;

(iv) these facts suggest that the K-S test may in all cases be more powerful than its alternative, the χ^2 test.

8.5 PERFORMANCE OF THE RESEARCH INSTRUMENTS

The performance of the research instruments could be evaluated by examining their empirical properties. The empirical properties could be used to determine whether to retain or modify the research instruments at the pretest level before the main data collection stage.

In the light of favourable pretest evidence on the internal consistency reliability, construct validity and the goodness of fit test for all the research instruments indicated in various sections of this chapter, a decision is hereby taken to retain the research instruments intact for use in the main data collection phase.

CHAPTER 9

MAIN DATA COLLECTION

9.0 MAIN DATA COLLECTION

9.1 INTRODUCTION

The same procedures used at the pretest level in data collection were repeated for the main data collection stage.

A number of the participating building designers and site personnel in the research study received the questionnaires through the clients. The returned questionnaires were posted to the University directly from the participants and others through the clients and then to the University.

For quite a number of projects, the questionnaires were sent direct to the participants in remote areas using addresses provided by the clients and those extracted from other sources.

With regards to projects situated in the Edinburgh area, the majority of the questionnaires were handed over to the participants, after a week or ten days, return visits were made for collection.

The main data collection phase has taken a considerable time period stretching right through to the end of September 1987.

An analysis of response rates is reported in Table 8. A total of 70 returns were received out of 114 Building Designer Questionnaire One for the participating architects (an overall response of 61.4%). 301 returns were received out of 498 Construction Site Questionnaire Two Parts I-IV for the participating site personnel (an overall response of 60.4%). Out of the 301 returns for this set, 78 were filled by site agents/managers (Part I), 72 by foremen category (Part II), 83 by site operatives (Part III), and 68 by Clerks of Works (Part IV).

Layne and Thompson [183] had found that a follow-up letter produced a better return, although the follow-up factor was not significantly related to the questionnaire response rate. Brook [50], however, recommended two follow-up mailings. Reminder postcards were therefore sent to subjects who failed to respond after ten days (see Appendix 1).

In many projects more than one architect was involved. Some sites with big schemes had assistant site agents/ managers. The Clerks of Works who participated in the research study were either an employee in the client's organisation or were employed by the project architect on behalf of the client.

All participants were assured that their responses would be kept confidential.

Table 8 Response Rates for Main Data Collection

CLIENT	PROJECT NUMBER	BUILDING DESIGNER QUESTIONNAIRE ONE			CONSTRUCTION SITE QUESTIONNAIRE TWO PARTS I TO IV		
		Number Delivered	Number Received	Response Percentage	Number Delivered	Number Received	Response Percentage
1	1	2	1	50%	4	4	100%
2	1	2	1	50%	8	6	75%
	2	1	1	100%	6	4	66.7%
3	1	2	1	50%	7	5	71.4%
	2	2	1	50%	5	4	80%
	3	2	1	50%	10	5	50%
	4	2	1	50%	6	5	83.3%
4	1	1	1	100%	4	4	100%
	2	2	1	50%	9	5	55.6%
5	1	2	1	50%	4	4	100%
	2	2	1	50%	12	6	50%
	3	2	1	50%	10	4	40%
6	1	1	1	100%	8	4	50%
7	1	2	1	50%	12	4	33.3%
	2	1	1	100%	8	5	62.5%
8	1	1	1	100%	6	4	66.7%
9	1	2	1	50%	4	4	100%
10	1	2	1	50%	7	4	57.1%
11	1	2	1	50%	8	5	62.5%
	2	1	1	100%	5	4	80%
12	1	1	1	100%	15	4	26.7%
13	1	2	1	50%	4	4	100%
	2	2	1	50%	7	4	57.1%
14	1	1	1	100%	11	5	45.5%
	2	2	1	50%	5	4	80%
	3	1	1	100%	6	4	66.7%
15	1	2	1	50%	6	5	83.3%
	2	2	1	50%	10	5	50%
16	1	1	1	100%	8	4	50%
17	1	2	1	50%	4	4	100%
	2	2	1	50%	6	4	66.7%
18	1	1	1	100%	7	4	57.1%
19	1	2	1	50%	9	5	55.6%
	2	1	1	100%	7	5	71.4%
20	1	1	1	100%	4	4	100%
	2	2	1	50%	5	4	80%
21	1	2	1	50%	6	4	66.7&
	2	2	1	50%	10	5	50%
22	1	2	1	50%	6	4	66.7%
23	1	2	1	50%	15	4	26.7%
	2	1	1	100%	4	4	100%
	3	2	1	50%	8	4	50%
24	1	2	1	50%	5	5	100%
	2	1	1	100%	7	4	57.1%
25	1	2	1	50%	4	4	100%

Table 8 (continued)

CLIENT	PROJECT NUMBER	BUILDING DESIGNER QUESTIONNAIRE ONE			CONSTRUCTION SITE QUESTIONNAIRE TWO PARTS I TO IV		
		Number Delivered	Number Received	Response Percentage	Number Delivered	Number Received	Response Percentage
26	1	1	1	100%	7	4	57.1%
27	1	1	1	100%	10	4	40%
	2	2	1	50%	8	4	50%
28	1	2	1	50%	8	4	50%
	2	1	1	100%	9	4	44.4%
29	1	1	1	100%	4	4	100%
30	1	1	1	100%	5	4	80%
31	1	2	1	50%	8	5	62.5%
	2	2	1	50%	4	4	100%
32	1	1	1	100%	6	4	66.7%
33	1	2	1	50%	8	4	50%
	2	2	1	50%	6	4	66.7%
	3	2	1	50%	8	5	62.5%
34	1	2	1	50%	6	4	66.7%
	2	1	1	100%	8	4	50%
35	1	1	1	100%	5	5	100%
36	1	2	1	50%	4	4	100%
37	1	2	1	50%	7	5	71.4%
	2	2	1	50%	10	4	40%
38	1	1	1	100%	6	4	66.7%
	2	2	1	50%	5	4	80%
39	1	2	1	50%	10	4	40%
	2	2	1	50%	13	4	30.8%
40	1	1	1	100%	5	4	80%
41	1	1	1	100%	6	4	66.7%
TOTAL	70	114	70	61.4%	498	301	60.4%

9.2 GEOGRAPHICAL DISTRIBUTION OF THE SITES

Table 9 shows the number of participating sites and the client's area of operation. The majority of the sites are situated in the Edinburgh area; followed closely by sites located in the Glasgow area. The projects vary in size from £500,000 to over £1,000,000.

9.3 DEMOGRAPHICS

Data on the demographic characteristics of the respondents were obtained. These could be used for analyses relating to differential work experiences among members and differential responses to them. Such data is reported in Table 10. The following sections discuss further information on this aspect for each group of the respondents.

9.3.1 BUILDING DESIGNERS

The job title of the building designers, in their respective organisations, ranges from 34 architects (48.6%), 27 partners (38.6%), 5 Directors (7.1%) and 4 others (5.7%) not specified. 3 (4.3%) have fellow membership, 31 (44.3%) have corporate membership, 15 (21.4%) have associate membership and 1 (1.4%) has student membership of related professional

Table 9 Geographical Distribution of Participating Sites

Clients' District Council Area of Operation	Number of Sites	Percentage %
Edinburgh	18	25.7
Midlothian	5	7.1
East Lothian	4	5.7
West Lothian	2	2.9
Glasgow	15	21.4
Dundee	6	8.6
Perth & Kinross	5	7.1
Kirkcaldy	2	2.9
Dunfermline	3	4.3
Falkirk	2	2.9
Kilmarnock & Loudoun	1	1.4
Angus	1	1.4
East Kilbride	2	2.9
Motherwell	1	1.4
Clydesdale	1	1.4
Stirling	2	2.9
TOTAL	70	100.0%

Table 10 Demographic Characteristics

RESPONDENTS	AGES							INDUSTRIAL EXPERIENCE (YRS)			SEX		TTL
	18-25	26-30	31-35	36-40	41-45	46-50	51-65	Range	Mean	S.D.	M	F	
Building Designers	3	8	11	18	14	9	7	2-40	23.4	15.7	68	2	70
Site Agents/ Managers	3	8	6	16	14	12	19	1-45	32.2	17.3	77	1	78
Foremen Category	4	10	4	11	13	15	15	5-55	28.5	11.9	72	-	72
Operatives	18	13	11	16	10	8	7	0-40	23.2	19.1	83	-	83
Clerks of Works	1	4	15	18	8	9	13	2-41	26.4	12.9	68	-	68

S.D. = Standard Deviation

institutions, i.e. RIBA, RIAS. With regards to qualification, 34 (48.6%) have Diploma Arch., 3 (4.3%) have HND in Architecture, 28 (40%) have B.Sc. Arch., and 5 (7.1%) have M.Sc. Arch. With regards to experience as a building designer 3 (4.3%) have less than 2 years, 13 (18.6%) have 2-5 years, 12 (17.1%) have 5-10 years and 37 (52.9%) have 10 years or more. 14 (20%) do not use RIBA Plan of Work in their design work, while 41 (58.6%) make use of the RIBA Plan of work in their design work. The percentage of time over total project period spent on each stage of the RIBA Plan of Work ranges from 1-2% on stage A, 3-4% on Stage B, 5-6% on Stage C, 7-10% on Stage D, 15-20% on Stage E, 20-30% on Stage F, 3-5% on Stage G, 2-5% on Stage H, 5-10% on Stage J, 25-35% on Stage K, 1-5% on Stage L and 1-2% on Stage M. 52 (74.3%) of the responding building designers are engaged in housing projects more than any other type of buildings. 3 (4.3%) are engaged more in Hospital buildings, 4 (5.7%) are engaged more in School buildings, 5 (7.1%) are engaged more in industrial buildings and 6 (8.6%) undertake design work for commercial buildings than any other type of building projects.

Approximate value of work under the control of the building designer in any one year ranges from: 2 (2.9%) designers and the value of work is under

£100,000; 5 (7.1%) £100,000-£250,000; 6 (8.6%) £250,000-£1m and 30 (42.9%) over £1m. 10 (14.3%) did not answer.

9.3.2 SITE AGENTS/MANAGERS

The job title for the respondents in this category are: 40 (51.3%) site agents; 18 (23.1%) site managers and 20 (25.6%) project managers. 49 (62.8%) are not members of any professional institutions, e.g. CIOB, RICS, ICE. Only 9 (11.5%) have corporate membership of related professional institutions. With regards to qualification, 34 (43.6%) have craft certificates in related trades; 10 (12.8%) have ONC; 15 (19.2%) have HNC; 3 (3.8%) have HND; 7 (9.0%) have B.Sc.; and 2 (2.6%) have M.Sc. With regards to experience as site agent/manager or project manager 5 (6.4%) have less than 2 years, 9 (11.5%) have 2-5 years; 15 (19.2%) have 5-10 years; 33 (42.3%) have 10 or more years; 16 (20.5%) did not answer.

Approximate value of work under the control of respondents in this category in any one year ranges from: 2 (2.6%) under £100,000; 6 (7.7%) £100,000-£250,000; 12 (15.4%) £250,000-£500,000; 25 (32.1%) £500,000-£1m; 26 (33.3%) over £1m. 7 (8.9%) did not give a figure.

9.3.3 SITE FOREMEN

Supervision is a full-time job to 33 (45.8%) of the foremen groups; 23 (31.9%) is a part-time job to them. The amount of time per week take up by full-time supervision varies from 8% to 90%; a mean of 42.5 hours with a standard deviation of 22.5.

9.3.4 SITE OPERATIVES

The site operative group consists of 5 (6.0%) labourers, 4 (4.8%) scaffolders, 1 (1.2%) drainlayer, 1 (1.2%) steel fixer, 20 (24.1%) brick-blocklayers, 5 (6.0%) roofers, 1 (1.2%) glazier, 22 (26.5%) carpenters, 7 (8.4%) plumbers, 3 (3.6%) electricians, 1 (1.2%) gas fitter, 3 (3.6%) painters, 5 (6.0%) plasterers, 2 (2.4%) wall tilers, 3 (3.6%) plant operators. 60 (72.3%) are certified skilled craftsmen/tradesmen, 13 (15.7%) apprentices and 10 (12.0%) did not respond. 50 (60.2%) are under the direct employment of the main contractors, 20 (24.1%) are employed by subcontractors and 13 (15.7%) are self-employed.

9.3.5 CLERKS OF WORKS

26 (38.2%) of the respondents in this category do not have membership of related professional institutions, e.g. CIOB, ICW. 35 (51.5%) are corporate members of the Institute of Clerk of Works (ICW), 7 (10.3%) did not respond. Experience as Clerk of Works of the respondents ranges from: 6 (8.8%) have less than 2 years, 8 (11.8%) have 2-5 years, 19 (27.9%) have 5-10 years, 32 (47.1%) have 10 or more years. With regards to qualification 17 (25%) have craft certificates; 28 (41.2%) have ONC; 14 (20.6%) have HNC and 9 (13.2%) have HND.

9.4 INTERNAL CONSISTENCY RELIABILITY OF RESEARCH INSTRUMENTS USING MAIN DATA

The method used to assess the reliability coefficients for the pretest data was utilised here at the main data stage. The default MODEL = ALPHA of the subprogram 'RELIABILITY' in SPSSX [257] was reactivated with some minor changes in the files. Table 11 reports the means, standard deviations and the internal consistency reliability coefficients of the research instruments using main data. On examining the table, it will be noted that all the reliability coefficients are within the acceptable limits.

Table 11 Means, Standard Deviations and Internal Consistency Reliability Coefficients of the Research Instruments using Main Data

SCALE/SUBSCALE		MEAN	STANDARD DEVIATION	INTERNAL CONSISTENCY RELIABILITY (CRONBACH'S ALPHA COEFFICIENT)
1.	Hackman and Oldham's [140] Core Job Characteristics			
1.1	Required Skill	4.21	1.10	0.72 (n=70)
1.2	Task Identity	5.54	1.32	0.73 (n=70)
1.3	Task Significance	5.91	0.82	0.51 (n=70)
1.4	Job Autonomy	5.94	1.10	0.68 (n=70)
1.5	Feedback from the Job	5.48	1.00	0.58 (n=70)
1.6	Dealing with Client & Others	5.81	1.30	0.67 (n=70)
1.7	Motivation Potential Score (MPS)	181.99	54.71	
2.	Briefing Information	27.19	8.38	0.78 (n=70)
3.	Knowledge of Results (Hackman and Oldham [140])	5.23	1.10	0.72 (n=70)
4.	Site Collaboration Interpersonal Relationships (Aram et al [8])			
4.1	Problem Solving through Support and Integration	4.02	0.59	0.52 (n=78)
4.2	Open, Authentic Communication	3.99	0.61	0.51 (n=78)
4.3	Knowledge-based risk taking	3.29	0.47	0.61 (n=78)
5.	Initiating Structure (Stogdill's [260])	40.78	4.93	0.76 (n=72)
6.	Internal Work Motivation (Hackman & Oldham [140])	4.94	0.99	0.80 (n=83)
7.	WORK-PLACE-SUPERVISION (Cammann et al [62])			
7.1	Control of Work	5.10	1.03	0.88 (n=83)

Table 11 (continued)

SCALE/SUBSCALE		MEAN	STANDARD DEVIATION	INTERNAL CONSISTENCY RELIABILITY (CRONBACH'S ALPHA COEFFICIENT)
7.2	WF - Goal Setting	5.37	0.76	0.68 (n=83)
7.3	WF - Problem Solving	5.17	0.96	0.81 (n=83)
7.4	WF - Subordinate Relations	4.76	0.77	0.66 (n=83)
7.5	Participation	4.70	1.04	0.69 (n=83)
8.	Supervision Satisfaction (Smith's [253])	3.81	0.64	0.82 (n=83)
9.	Role Strain (Kahn et al [171])	2.73	0.60	0.81 (n=68)
10.	Role Clarity (Berkowitz [23])	4.17	1.21	0.83 (n=68)

WF = Work Facilitation
n = no of cases

Comparing Table 3 and Table 11, it will be noted that the majority of alpha coefficients for the research instruments at main data stage have been in the incremental direction.

The research instruments both at pretest level and main data stage have performed satisfactorily. This could easily be identified by comparing Table 3 and Table 11 with Table 4 (pre-validated scales for construct validation purposes).

9.5 GOODNESS OF FIT TEST USING MAIN DATA

The specification K-S(NORMAL) in SPSSX [257] was reactivated this time using the main data with the intention to undertake Kolmogrov-Smirnov goodness of fit test. It was aimed at investigating whether the observed data came from the theoretical normal distribution specified in the study.

Table 12 reports the values of most extreme differences and K-S Z using the two-sided K-S test.

From Table B (in the Appendix) provided by Conover [83], the critical region of significance level of size alpha = 0.01 corresponds to the value $1.63/\sqrt{n}$ (where n = number of cases) at 0.99 quantile. For all the scales 1-3 in Table 12 the number of cases is 70. Size alpha = 0.01 corresponds to $1.63/\sqrt{70} = 0.195$. All the values of most

Table 12 Kolmogrov-Smirnov (K-S) Goodness of Fit Test (NORMAL) Using Main Data

SCALE/SUBSCALE		MOST EXTREME DIFFERENCES			K-S Z	Number of Cases
		Absolute	Positive	Negative		
1.	Design Core Job Characteristics					
1.1	Required Skill	0.142	0.142	-0.094	1.072	70
1.2	Task Identity	0.126	0.122	-0.126	0.969	70
1.3	Task Significance	0.137	0.092	-0.137	1.034	70
1.4	Job Autonomy	0.167	0.165	-0.167	1.308	70
1.5	Feedback from the Job	0.097	0.075	-0.097	1.732	70
1.6	Dealing with Client & Others	0.217	0.181	-0.217	1.693	70
2.	Briefing Information	0.189	0.189	-0.102	1.566	70
3.	Knowledge of Results	0.0813	0.064	-0.0813	0.675	70
4.	Site Collaboration Interpersonal Relationships					
4.1	Problem Solving through Support and Integration	0.136	0.073	-0.136	1.059	78
4.2	Open, Authentic Communication	0.140	0.119	-0.140	1.097	78
4.3	Knowledge-based risk taking	0.152	0.152	-0.137	1.155	78
5.	Initiating Structure	0.123	0.122	-0.122	0.950	72
6.	Internal Work Motivation	0.152	0.076	-0.152	1.277	83
7.	WORK-PLACE-SUPERVISION					
7.1	Control of Work	0.147	0.078	-0.147	1.254	83
7.2	WF - Goal Setting	0.158	0.108	-0.158	1.351	83
7.3	WF - Problem Solving	0.159	0.133	-0.159	1.349	83
7.4	WF - Subordinate Relations	0.089	0.056	-0.089	1.688	83

Table 12 (continued)

SCALE/SUBSCALE		MOST EXTREME DIFFERENCES Absolute	Positive	Negative	K-S Z	Number of Cases
7.5	Participation	0.177	0.090	-0.177	1.383	83
8.	Supervision Satisfaction	0.109	0.089	-0.109	0.848	83
9.	Role Strain	0.235	0.235	-0.126	1.922	68
10.	Role Clarity	0.083	0.083	-0.068	0.697	68

WF = Work Facilitation

extreme differences in column four in Table 12 are less than 0.195. The null hypothesis is therefore accepted, that is the observed data in these cases have come from a theoretical distribution of the population specified in the study.

For all the scales 4.1 to 4.3 in Table 12, the number of cases is 78. Size alpha = 0.01 corresponds to $1.63/\sqrt{78}$ = 0.185. All the values of most extreme differences in these cases in the Table are less than 0.185. The null hypothesis is therefore accepted.

For the scale 5 in Table 12, the number of cases is 72. Size alpha = 0.01 corresponds to $1.63/\sqrt{72}$ = 0.192. The values of most extreme differences in these cases in the table are less than 0.192. The null hypothesis is therefore accepted.

For the scales 6 to 8 in Table 12, the number of cases is 83. Size alpha = 0.01 corresponds to $1.63/\sqrt{83}$ = 0.179. All the values of most extreme differences in these cases in the table are less than 0.179. The null hypothesis is therefore accepted.

For scales 9 and 10 in Table 12, the number of cases is 68. Size alpha = 0.01 corresponds to $1.63/\sqrt{68}$ = 0.198. The value of most extreme differences for scale 10 is 0.083 which is less than 0.198. The null hypothesis is here accepted. For scale 9, the value of most extreme differences is 0.235 which is greater than 0.198. The null hypothesis is rejected for this scale. But it could be argued that the questionnaire was filled by the same respondents at the same time with the rest of the items. Therefore, the observed data must have reasonably come from a theoretical distribution of the population specified in the study as a whole.

Moreover, it will be noted that all the K-S Z values in Table 12 are within the acceptable limits tabulated by Smirnov [255] for the larger the value of Z, the less likely it is that the observed and theoretical distributions are the same [162].

9.6 ITEM ANALYSIS USING MAIN DATA

The procedure used to investigate relations among the items forming the briefing information scale at the pretest level in Section 8.3.3.1 was repeated for the same items at the main data stage. Measures of the items were obtained from 70 respondents. A correlation matrix reported in Table 13 for the items was obtained by reactivating the subprogram 'FACTOR' in SPSSX [257]. On the whole, the items intercorrelate positively, consistently and quite significantly. As suggested by Nunnally [223] if all the proposed measures correlate highly with one another, it can be concluded that all measure much the same thing. It should be recalled

Table 13 Correlation Matrix of Briefing Information Items Using Main Data

Items	1	2	3	4	5	6	7	8	9
1	-								
2	.623	-							
3	.723	.605	-						
4	.353	.666	.420	-					
5	.804	.572	.661	.393	-				
6	.624	.587	.568	.591	.622	-			
7	.699	.613	.889	.479	.679	.618	-		
8	.523	.500	.604	.455	.350	.499	.600	-	
9	.776	.544	.644	.444	.758	.577	.678	.455	-

p > .001

from Table 11 that the briefing information scale has an internal reliability coefficient of 0.78 (n=70) magnitude. The detail of the item total statistics shown in Table 14 was obtained using subprogram 'RELIABILITY' in SPSSX [257].

Taking this and the high correlation among the items into account, it can be deduced that the scale at main data stage performed well, and it measures what it has been designed to measure.

Table 14 Item-total Statistics for Briefing Information Scale Using Main Data

ITEM	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
1	23.7571	48.8532	.7935	.8225	.7024
2	23.6286	47.4542	.8069	.8332	.6971
3	23.9571	50.9981	.6525	.7924	.7259
4	24.1143	71.0302	-.1113	.5054	.8174
5	24.5000	56.3406	.4444	.5862	.7603
6	24.6571	62.6344	.2964	.6367	.7777
7	24.4000	51.9246	.6642	.7852	.7255
8	25.2143	50.5186	.6045	.6241	.7336
9	24.2571	73.3532	-.2675	.1985	.8169
Cronbach's Alpha Coefficient = 0.78					

CHAPTER 10

MAIN DATA ANALYSIS

10.0 MAIN DATA ANALYSIS

10.1 INTRODUCTION

Two sets of analyses were performed. First a factor analysis to explore the underlying dimensions of the research instruments was performed. Secondly, multivariate analysis in multiple regression was used to establish the relative influences of the independent variables upon the criteria variable.

10.2 APPROACH TO DATA ANALYSIS

The Statistical Package for the Social Sciences (SPSS), the system of computer programmes was used in data analysis both at pretest and main data levels. The data was originally coded into the computer using SPSS package. Later, the data was transferred to SPSSX release 2.1 package, at the advent of the University's new computer facilities - 'Dec VaxCluster'.

The bulk of the changes made between SPSS and SPSSX were in the areas of file definition and data transformation. Minor changes were made on the procedure commands in order for the SPSS job to work well in SPSSX package.

The SPSSX was used in data analysis because of the following reasons:

a) the programme design is computationally efficient,

b) the logic and syntax of the system are suitable for analysing the data,

c) the system provides statistical procedures and data-management facilities tailored to the particular needs of empirical social type research,

d) the package is continuously updated to take account of new developments in statistical analysis (as the case from SPSS to SPSSX).

10.3 FACTOR ANALYSIS

Factor analysis for a number of standardised questionnaire was undertaken in order to explore the underlying dimensionality. The extent to which empirical findings correspond to the hypothetical structure of the questionnaire outlined in this research will be facilitated by the exploration of the factor structure.

For the interpretation of the factor structure the following basic requirements suggested by Kim and Mueller [177], Child [70] and Nie et al [222] were outlined:

a) a statement of the direct method used

b) details about the entries in the leading diagonals

c) the criteria for deciding on the number of factors to be extracted

d) the criteria for choosing the significant loadings in each factor

e) the rotation method adopted.

In the present research principal component analysis with iterations and varimax rotation was used. Factoring was terminated in accordance with Kaiser's normalisation that eigen values remain greater or equal to one whenever applicable. The criteria for choosing significant loadings was followed where a loading is more or equal to $\pm$ 0.30.

The standardised scales were factor analysed by invoking the subprogram 'FACTOR' in SPSSX [257] and the results are reported in Appendix 3.

10.3.1 FACTOR ANALYSIS ON THE WHOLE SAMPLE

The previous discussion on factor analysis concerns the exploration of the underlying dimensionality of each of the standardised scales forming the research instruments. In this section the possibility of factor analysing the scales in the whole sample will be briefly reviewed and identify any practical difficulties.

Factor analysis is based on the fundamental assumption that some underlying factors are responsible for the covariation among the observed items. There are points in factor analysis where decisions must be made regarding the statistical confidence to be placed in results. An important point to take into account in factor analysis is the sample size. As factor analysis employs Pearson Product-Moment Correlation as its starting point, the distribution of the variables should be continuous and reasonably normal [222]. Kaiser and Rice [294] indicated that the number of subjects should exceed the number of variables. Nunnally [223] was more specific saying that factor analysis requires a minimum of five subjects for each item and if the number of subjects is not much greater than the number of items, the factors are likely to occur purely by chance. Stewart et al [295] noted that a lower limit of the sample size for factor analysis is three subjects for each variable.

Taking the sample size in this research into account, factor analysis of the whole sample was not undertaken on the basis of items forming the research instruments due to the violation of the rule suggested by Nunnally [223]. Moreover, in this research there were five different groups of respondents each with their different set of questionnaires. And the sample size from each group varies. Their response to a standard test may be different than that produced by amalgam of different items from a number of tests. The foregoing indicates one of the practical limitations in this research. Factor analysis was therefore restricted to individual variables as discussed in Appendix 3.

The next section concerns the limitations of factor analysis.

10.3.2 LIMITATIONS OF FACTOR ANALYSIS

It would be appropriate at this point to mention some cautions regarding the results of the factor analysis.

Factor analysis is too complex to describe, so only a brief outline is being given here based only on existing literature (e.g. Nie et al [222], Child [70]). It is suggested here that high margins of error prevailed in tests of human behaviour. Human behaviour and perceptions cannot be accounted for with some degree of precision. As such the measure here, as they are, are more numerous and are likely to have greater margins of error.

Nunnally [223] suggested that the number of subjects should exceed the number of items. He pointed out that factor analysis requires about five subjects for each item, and if the number of subjects is not much larger than the number of items, the factors are likely to occur by chance.

Another limitation of factor analysis concerns the selection of subjects. If subjects are relatively heterogeneous with respect to age, sex and education, factors sometimes are produced by differences in these regards. Whether one should permit samples of persons to be heterogeneous with respect to such variables depends on the population over which the results of factor analysis are to be generalised.

Overlapping of items on factors is yet another limitation. This happens most frequently where it is common practice to derive a number of different scales from the same items. Though all the scales used here are standardised scales, utilised in many research settings across different samples over time, and have empirical evidence of reliability and validity, yet many of the items load on more than one factor.

Another limitation of factor analysis is the employment of a method of rotation that does more to obscure the actual groupings of items than to adequately depict them. Nunnally [223] have mentioned anomaly on oblique rotation where in order to have a simple looking set of results the pattern matrix rather than the actual matrix of factor loadings (here taken as factor structure) is frequently interpreted.

Though it is important to be mindful of the limitations outlined above, it is equally important, as in any other scientific study, that we should be looking for improvements in the precision of the measures at our disposal and not abandoning them, particularly in the absence of anything better.

10.4 MULTIPLE REGRESSION ANALYSIS

10.4.1 INTRODUCTION

In this section, multiple regression will be applied to main data analysis. Specifically, multiple regression will be applied in hypothesis testing.

The regression analysis is a general statistical technique through which relationship between criterion variable and a set of independent variables could be analysed. The technique is used here for explanatory purposes of the phenomenon and to evaluate the contribution of a specific variable and set of variables.

Regression analysis is based on several important assumptions. Before embarking upon the regression analysis, the regression assumptions are to be fulfilled if appropriate estimate of the population parameters and tests of statistical significance are to be accomplished. The following section concerns the regression assumptions and their verifications.

10.4.2 THE REGRESSION ASSUMPTIONS

The regression assumptions that should be met to be able to appropriately estimate the population parameters and conduct tests of statistical significance are as follows:

a) Measurement of variables at minimum interval level;
b) absence of perfect multicollinearity;
c) linearity of relationships;
d) additivity of relationships;
e) error term disturbances
    i) have zero mean,
    ii) are homoscedastic,
    iii) are normally distributed,
    iv) are not autocorrelated;
f) absence of specification errors.

These regression assumptions should be of considerable concern and an issue for examination as difficulties arise in the regression analysis when the assumptions are violated. Therefore, verification of these assumptions should be viewed as an integral part of a regression analysis and a matter of considerable importance in so far as violation of the assumptions without any remedial action could have impending repercussions on the parameter estimates, statistical tests of significance and confidence intervals as outputs from regression exercise.

It is not inconceivable to encounter a situation in which there is one or more departure from the given set of regression assumptions, considering the nature of field data. It is possible therefore that one or more violations of the assumptions could be encountered. Without any evidence to support such an argument, there is every reason to be equivocal over the attainment of the regression assumptions by any set of research data, particularly field data.

In accordance with the above arguments, it is decided here to ratify the extent of compliance with the stated regression assumptions. The following sections concern each of the assumptions in turn.

10.4.2.1 Measurement of Variables at Minimum Interval Level

When measurement issue is being discussed, the idea that usually comes to mind is the assigning of numbers to observations in such a way that the numbers are amenable to analysis by manipulation or operation according to certain rules.

Most discussions on the 'level of measurement' issue can be traced back to the work of Stevens [258]. While many people have written about the idea of measurement, the variety of approaches that are involved is still impressive. Essentially, one's objective determines, to some extent, how one enters the argument.

There have been considerable arguments in the literature to the effect that variables need not have to be absolutely interval or ratio before parametric statistics can be considered. Labowitz and Hagedorn [179] reassured that an ordinal variable his little distortionary effect on the statistical tests provided the ordinal measure bears a monotonic relationship with the base reference scale. Bohrstedt and Carter [35] have indicated that, the higher power of parametric statistics relative to nonparametric statistic appears to offset or diminish the probability of the occurrence of inferential errors arising from the involvement of ordinal measure. Parametric statistics are good for ordinal variables and even nominal variables on the condition that the dependent variable is ordinal, interval or ratio [35]. Incidentally, the dependent variable, quality achievement in the present research is ordinal.

Because most of the variables that interest us in a research of social scientific type are continuous at the conceptual level and are reasonably close to normally distributed in the population of interest, there is no reason to eschew the use of parametric statistics [34]. All the variables embodied in this research were measured using summated scales which are strictly speaking at ordinal level of measurement. However, research variables with multiple categories in their measures may be confidently regarded as interval variables on the assumptions of equality of intervals between categories. The assumption of interval equality is fairly satisfactory on the ground that as a relationship approximates linearity so would the intervals approaching equality [175].

The variables of greatest interest in a research of this type are latent unobserved constructs, as indicated earlier. And most of these constructs are conceptualised to be continuous at the latent level, even though they are usually manifestly measured as discrete variables. If the constructs are continuous they must also be interval [34]. Importantly, the use of factor analysis and other multivariate techniques require that one's dependent variables be continuous and distributed normally for each outcome associated with the independent variables [34].

To summarise, most of the central constructs in this study are conceptualised as continuous, and their distributions are such that the application of parametric statistics to their analyses will not result in seriously biased estimates.

10.4.2.2 Absence of Perfect Multicollinearity

Multicollinearity is concerned with the inter-relationships among independent variables. It arises whenever two or more independent variables used in a regression are not independent but are correlated. Perfect multicollinearity exists when absolute linear relationships (that is $r = 1.0$) are observed. This creates estimation problems because it produces large variances for the slope estimates and consequently, large standard errors. Fortunately, perfect collinearity is rarely found in a research of social scientific type. On the other hand, when the linear relationship is zero (that is $r = 0.0$) there is non-interrelationships of the independent variables which implies the complete absence of multicollinearity.

Multicollinearity is probably present in all regression analysis, since the independent variables are unlikely to be totally uncorrelated. Thus whether or not multicollinearity is a problem depends on the degree of collinearity. That is, the problem is more a matter of degree. Furthermore, it seems from the literature that the problem of multicollinearity is not entirely conclusive.

10.4.2.2.1 Detecting high multicollinearity

Certain symptoms may indicate the probable presence of multicollinearity. One rather sure symptom is a substantial R^2 (coefficient of multiple determination) for the equation with none of few statistically significant coefficients; secondly, a dramatic change in coefficient magnitudes when independent variables are introduced or excluded in the equation; thirdly, unanticipatedly large or small coefficient magnitudes. A fourth alert is a coefficient with a 'wrong' sign; and lastly high intercorrelations among the independent variables ($r = 0.80$ and above) [188].

While the above symptoms may tentatively suggest that the independent variables are multicollinear, they do not technically confirm that the problem exists. A preferable test and a more definitive methodology is to regress each independent variable on all other independent variables in the given set, and look at the R^2s for these regressions. If any are close to unity, there is a high degree of multicollinearity present [246]. When high multicollinearity turns out to be present, the R^2 technique clearly identifies the source of the problem by pinpointing which independent variables are approximately linearly related to others.

To detect the extent of multicollinearity among the independent variables, the following three regression equations are formulated to represent the research model. The multivariate regression equations are:

(1) $$QA = a + b_1 SKR + b_2 TID + b_3 TSG + b_4 AUT + b_5 FBC + b_6 DLC + b_7 BRI + e$$

(2) $$QA = a + b_1 PSSI + b_2 OAC + b_3 KBR + b_4 INS + b_5 RAU + b_6 RCL + e$$

(3) $$QA = a + b_1 IWM + b_2 SCW + b_3 SGS + b_4 SPS + b_5 SSR + b_6 SPT + b_7 SAT + e$$

where QA = Quality Achievement

a = intercept

$b_{1,2,3...i}$ = partial regression coefficients

SKR = Required Skill

TID = Task Identity

TSG = Task Significance

AUT = Job Autonomy

FBC = Feedback from the job

DLC = Dealing with Client & Others

BRI = Briefing Information

PSSI = Problem Solving through Support & Integration

OAC = Open Authentic Communication

KBR = Knowledge-Based Risk taking

INS = Initiating Structure

RAU = Role Strain

RCL = Role Clarity

IWM = Internal Work Motivation

SCW = Supervision - Control of Work

SGS = Supervision - Goal Setting

SPS = Supervision - Problem Solving

SSR = Supervision - Subordinate Relation

SPT = Supervision - Participation

SAT = Supervision Satisfaction

The above regression equations provide three subsets of independent variables which are candidates for multicollinearity check. The 'REGRESSION' procedure in SPSSX [257] was utilised with mean substitution of missing values to regress each independent variable on the remaining independent variables in each subset in order to compute the R^2 for each regression. The R^2 values so computed are reported in Table 15. The

Table 15 Computed R^2 Values for the Assessment of Multicollinearity

No.	Regression Equation	R^2
1		
(i)	SKR = 4.42 - 0.06TID + 0.20TSG + 0.04AUT + 0.06FBC - 0.23DLC - 0.06BRI	.08
(ii)	TID = 4.74 - 0.08SKR - 0.19TSG + 0.22AUT + 0.21FBC + 0.01DLC - 0.09BRI	.10
(iii)	TSG = 3.31 + 0.10SKR - 0.08TID + 0.08AUT + 0.14FBC + 0.21DLC + 0.06BRI	.18
(iv)	AUT = 2.34 + 0.03SKR + 0.13TID + 0.11TSG + 0.26FBC + 0.17DLC - 0.09BRI	.20
(v)	FBC = 2.49 + 0.04SKR + 0.12TID + 0.21TSB + 0.26AUT - 0.10DLC - 0.02BRI	.10
(vi)	DLC = 3.16 - 0.27SKR + 0.01TID + 0.52TSG + 0.28AUT - 0.16FBC - 0.03BRI	.21
(vii)	BRI = 3.70 - 0.06SKR - 0.07TID + 0.13TSG - 0.13AUT - 0.03FBC -0.03DLC	.04
2		
(i)	PSSI = 1.46 + 0.41OAC + 0.21KBR - 0.04INS - 0.04RAU + 0.09RCL	0.20
(ii)	OAC = 3.35 + 0.32PSSI - 0.12KBR - 0.03INS + 0.02RAU - 0.05RCL	.14
(iii)	KBR = 3.98 + 0.12PSSI - 0.09OAC - 0.03INS - 0.03RAU + 0.03RCL	.06
(iv)	INS = 4.47 - 0.04PSSI - 0.04OAC - 0.06KBR - 0.02RAU + 0.05RCL	.02
(v)	RAU = 5.31 - 0.45PSSI + 0.23OAC - 0.56KBR - 0.17INS + 0.44RCL	.16
(vi)	RCL = -0.45 + 0.72PSSI - 0.48OAC + 0.37KBR + 0.35INS + 0.32RAU	0.21
3		
(i)	IWM = 1.77 + 0.15SCW + 0.50SGS + 0.45SPS - 0.12SSR - 0.08SPT 0.22SAT	.57
(ii)	SCW = 0.80 + 0.14IWM + 0.60SGS + 0.07SPS + 0.03SSR + 0.22SPT + 0.15SAT	.59
(iii)	SGS = 0.17 + 0.29IWM + 0.38SCW + 0.44SPS + 0.15SSR - 0.12SPT - 0.02SAT	.53
(iv)	SPS = 0.12 + 0.15IWM + 0.02SCW + 0.25SGS + 0.13SSR + 0.07SPT + 0.10SAT	.55

Table 15 continued

No.	Regression Equation	R^2
3		
(v)	SSR = 2.43 - 0.05IWM + 0.01SCW + 0.11SGS + 0.17SPS + 0.11SPT + 0.32SAT	.30
(vi)	SPT = 2.42 - 0.12IWM + 0.35SCW - 0.31SGS + 0.30SPS + 0.39SSR - 0.08SAT	.18
(vii)	SAT = 2.12 - 0.09IWM + 0.07SCW - 0.01SGS + 0.12SPS - 0.02SPT + 0.30SSR	.18

values for the R^2 varies from 0.04 to 0.21 for the first subset of the independent variables.

For the second set, the range is 0.02 to 0.21. For the third set the range is from 0.18 to 0.59. The results indicate the extent of multicollinearity with the highest value of R^2 of 0.59 which is far from unity. It could be concluded that, multicollinearity is therefore not a problem directly in the research data.

10.4.2.3 Linearity of Relationships

Linearity is the assumption that for each independent variable, the amount of change in the mean value of the dependent variable associated with a unit increase in an independent variable, holding all other independent variables constant, is the same regardless of the level of the independent variable [24]. In other words, the assumption of linearity demands that the set of independent variables is related to the dependent variable in a linear manner. In contrast, if for any independent variable in a model, the change in the mean value of the dependent variable associated with a unit increase in the particular independent variable varies with its value, it implies that, the independent variable is nonlinearly related to the dependent variable. A nonlinear relationship produces biased parameter estimates. To overcome such problems, transformation of the original variables in such a way that the resultant relationships among the transformed variables become linear is usually undertaken [246]. Nie et al [222] provided available transformation functions as common long, square root, square and reciprocal. Common log function is by far the most popular [222].

There are techniques that can be used to detect non-linearity even when the precise nature of the relationship cannot be anticipated beforehand. Symptoms of nonlinearity may be identified by visual inspection of scatterplots of standardised residuals versus standardised value of the predicted variables [24]. Sometimes, nonlinearity will be sufficiently striking so that it is clearly evident that the curve that best fits the pionts on the graph does not take the form of a line. What is of interest in this regard is the overall shape of each plot.

10.4.2.3.1 Test for curvilinearity

Regression with dummy variables can provide an important technique when non-specific curvilinear relationships are encountered or suspected. This procedure calls for the 'test of curvilinearity' which could be used if curvilinearity is suspected. Such test is provided by Nie et al [222]. As the independent variables in the present research are measured as discrete variables, the relevant F test provided by Nie et al [222] is:

$$F = \frac{(R^2 \text{ with dummy variables} - R2 \text{ with original variables})/(K-1)}{(1 - R^2 \text{ with dummy variables})(N-K-1)}$$

with (K-1) and (N-K-1) degrees of freedom (df),

where R^2 = coefficient of determination;

N = sample size;

K = number of dummy variables.

Using the above test, one can identify whether the proportion of variance in the dependent variable contributed by some curvilinear relationship outweighs that contributed by supposedly linear relationship. The computed F statistic is to be compared with the tabulated value of F. If the computed value of the F statistic exceeds the tabulated value of F for the appropriate degrees of freedom at the given level of significance, the alternative hypothesis of curvilinearity will be accepted, and the null hypothesis of linearity is rejected.

To explore the extent of curvilinearity for the sole aim for linearity assumption a total of 23 residuals scatterplots were produced by activating the 'REGRESSION' procedure incorporating the 'SCATTERPLOT = subcommand' in SPSSX [257]. The residual scatter plots are depicted in Figure 17 displayed in (a) to (w). Each of the scatterplots (a) to (w) were examined for a systematic patter of curvature, but none was found to be present in the research data. Hence, the need for the aforementioned F test is not required here. To summarise, it could be deduced that linearity assumption is satisfied by the research data.

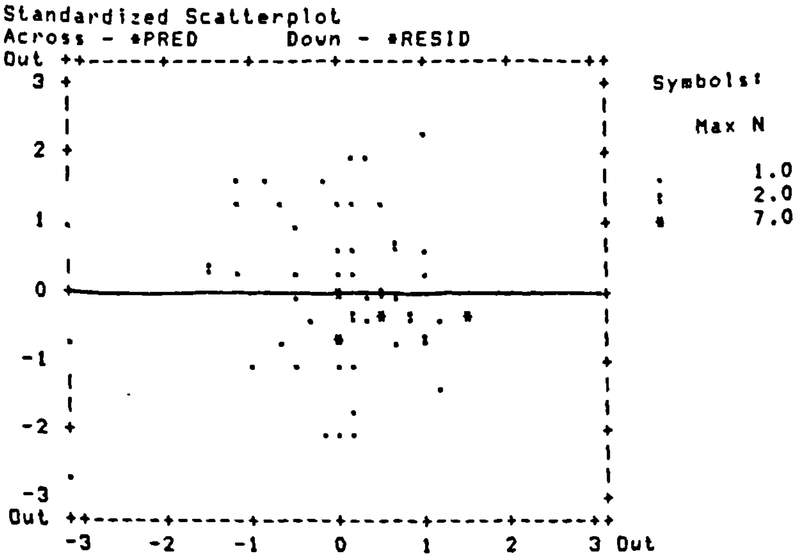
10.4.2.4 Additivity of Relationship

Additivity is the assumption that for each independent variable, the amount of change in the dependent variable associated with a unit increase in the dependent variable (holding all other independent variables constant) is the same regardless of the values of the other independent variables in the equation.

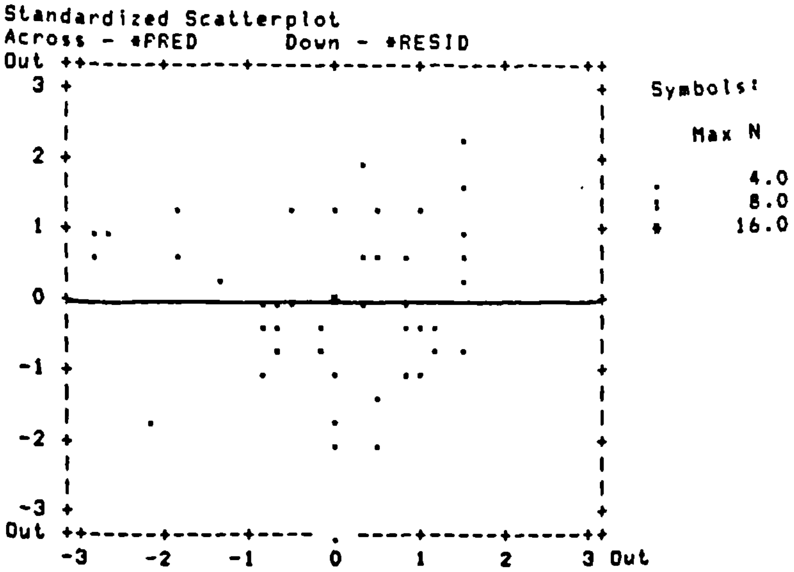
The key question one must ask in deciding if there is reason to expect non-additivity is whether for each independent variable the slope of the relationship between the dependent and independent variable can be expected to vary depending on the 'context' [24]. If theory suggests that the change in the dependent

Figure 17: Residual Scatterplots for Standardised Residuals (*RESID) versus Standardised Predicted (*PRED) Values of the Dependent Variable QA (a) to (w)

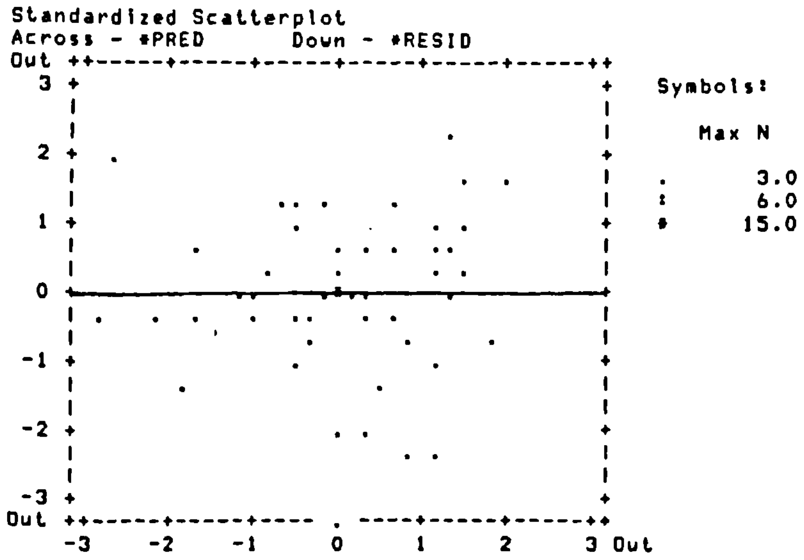
16-MAR-88 MULTIPLE REGRESSION 05
14:42:25 Heriot-Watt University DEC VAX-8800 VMS V4.5



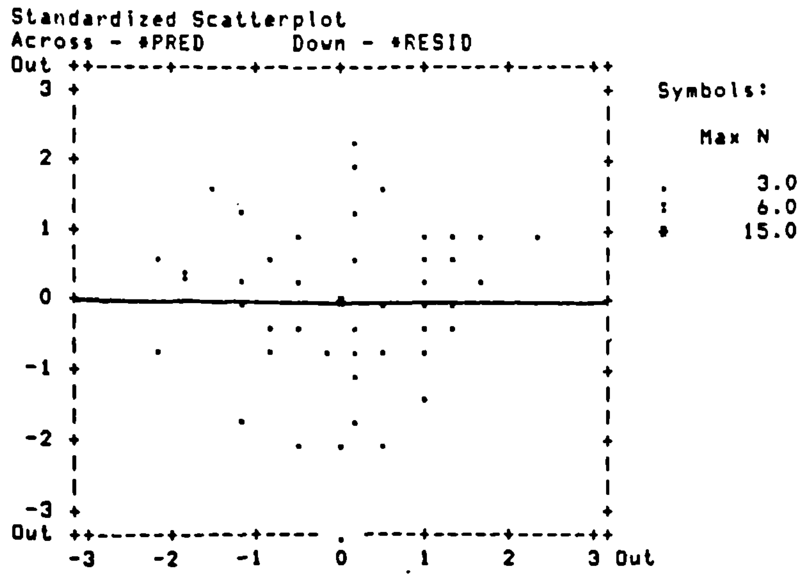
(a) SKR - QA relationship



(b) TID - QA relationship



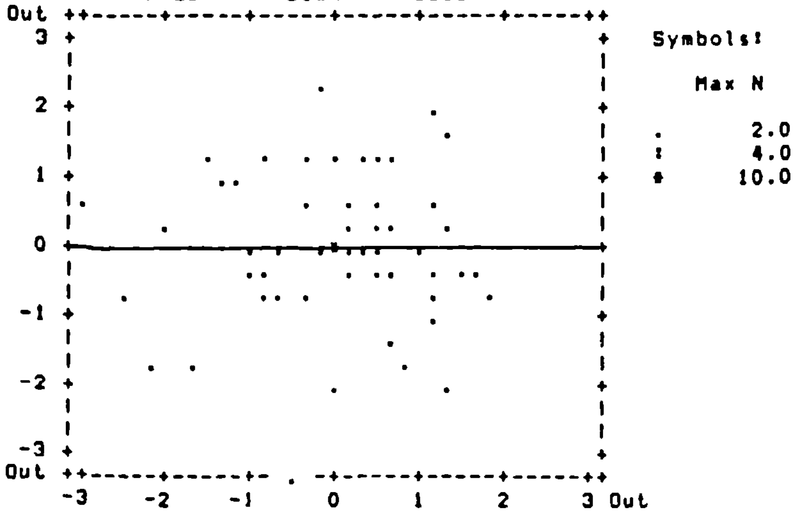
(c) TSG - QA relationship



(d) AUT - QA relationship

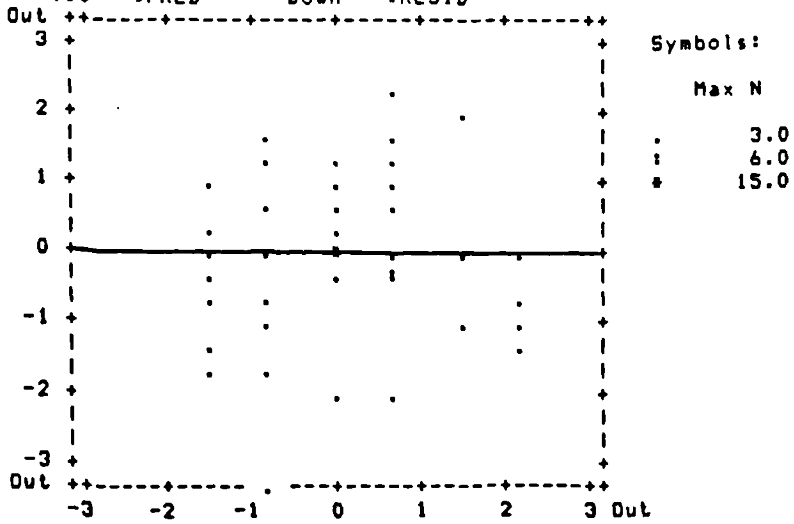
16-MAR-88 MULTIPLE REGRESSION 05
14:42:26 Heriot-Watt University DEC VAX-8800 VMS V4.5

Standardized Scatterplot
Across - *PRED Down - *RESID



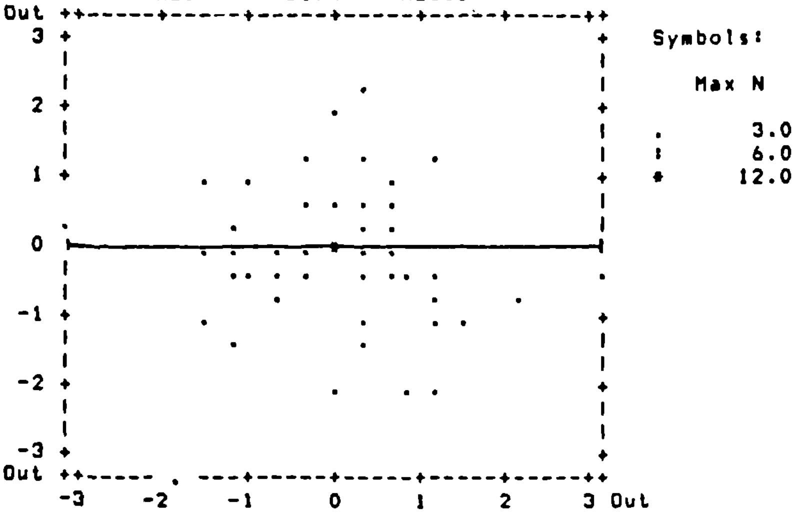
(e) FBC - QA relationship

Standardized Scatterplot
Across - *PRED Down - *RESID



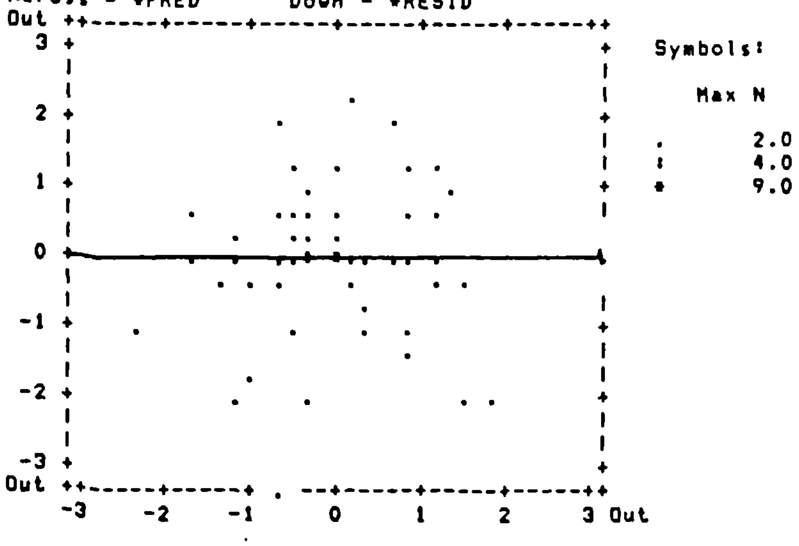
(f) DLC - QA relationship

Standardized Scatterplot
Across - *PRED Down - *RESID

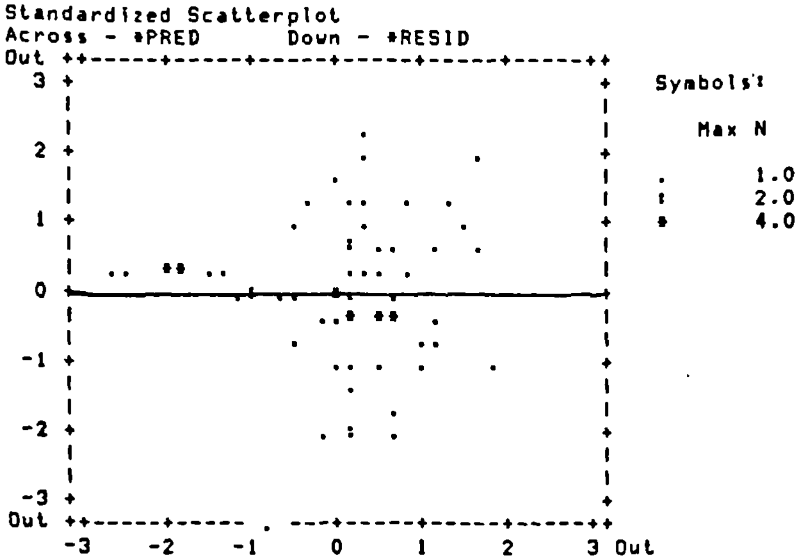


(g) BRI - QA relationship

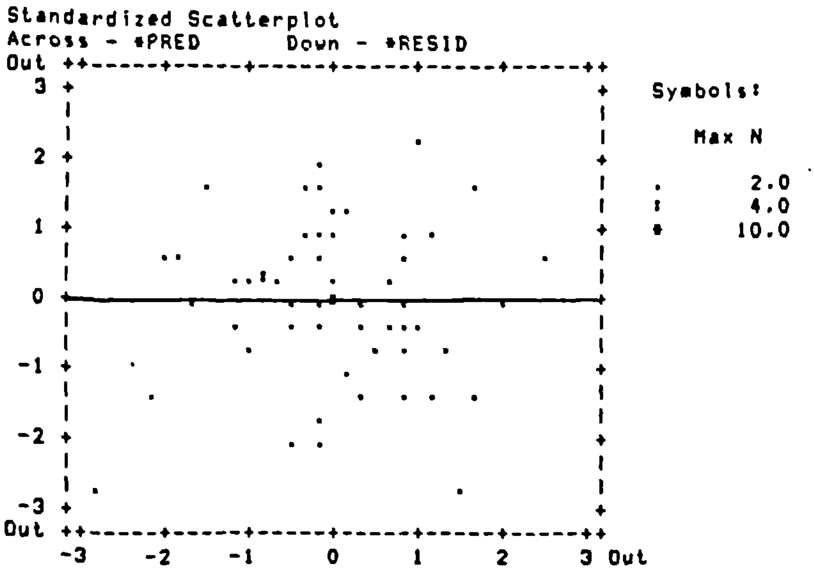
Standardized Scatterplot
Across - *PRED Down - *RESID



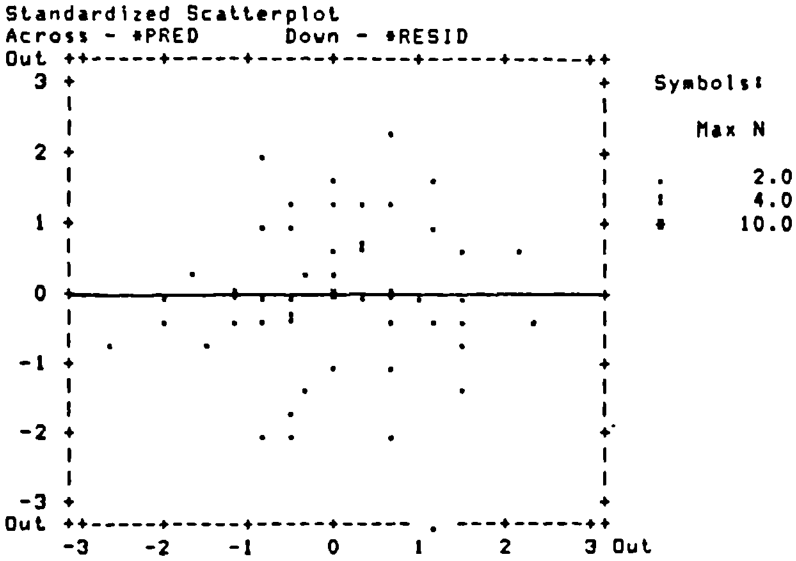
(h) PSSI - QA relationship



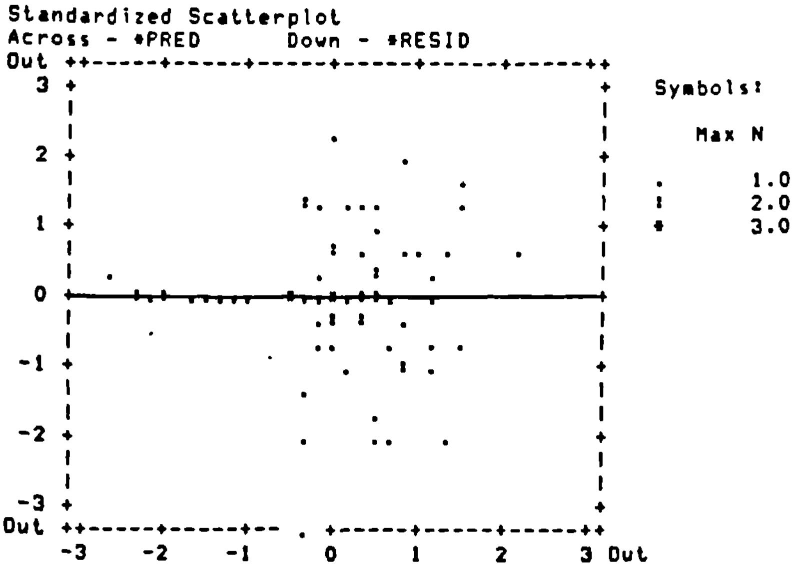
(i) OAC - QA relationship



(j) KBR - QA relationship

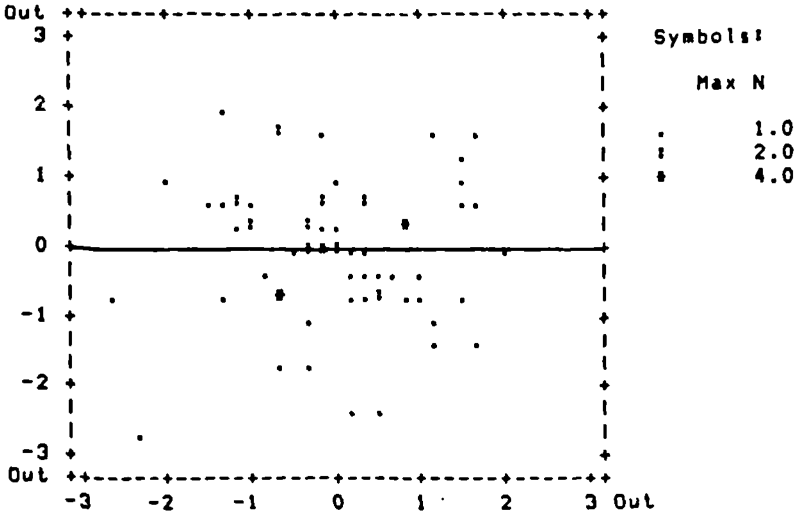


(k) INS - QA relationship



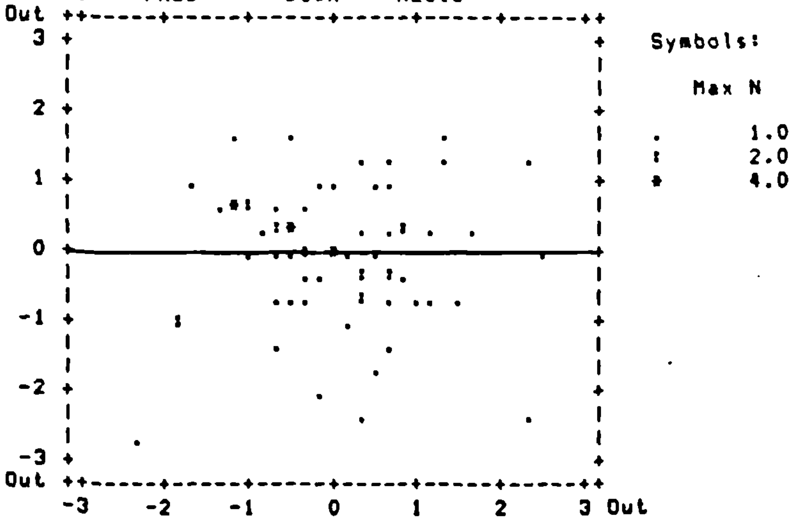
(l) RAU - QA relationship

Standardized Scatterplot
Across - *PRED Down - *RESID

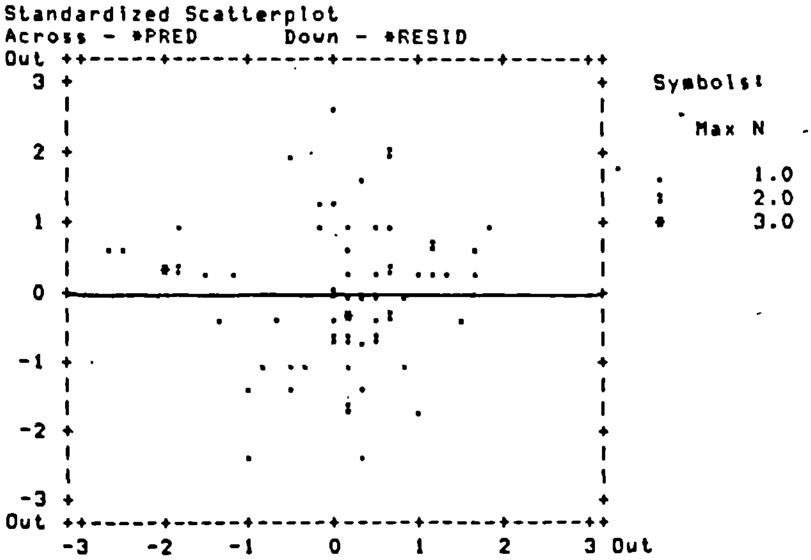


(m) RCL - QA relationship

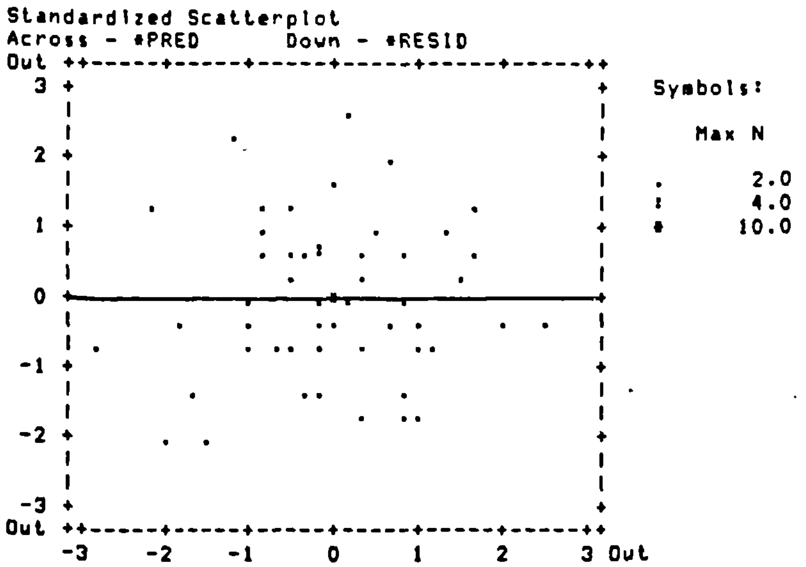
Standardized Scatterplot
Across - *PRED Down - *RESID



(n) IWM - QA relationship

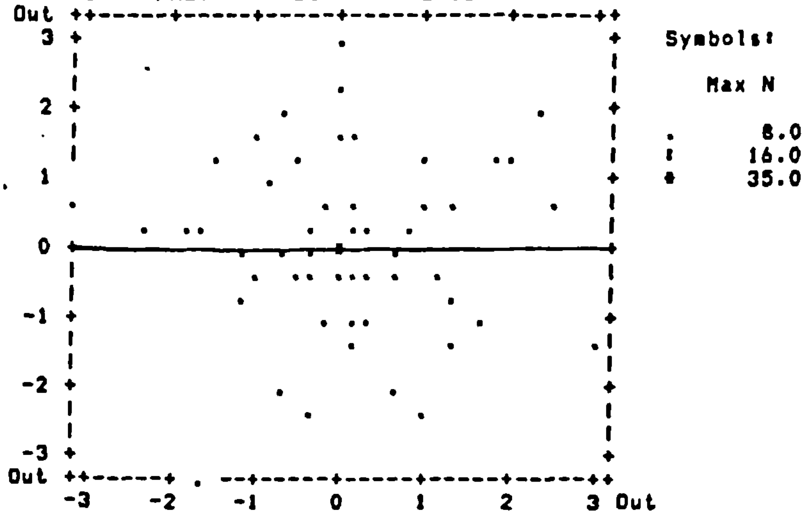


(o) SCW - QA relationship



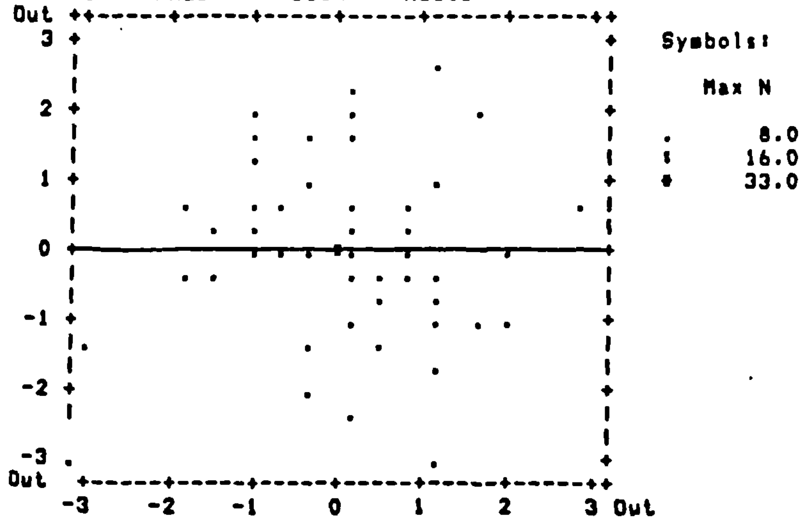
(p) SGS - QA relationship

Standardized Scatterplot
Across - *PRED Down - *RESID

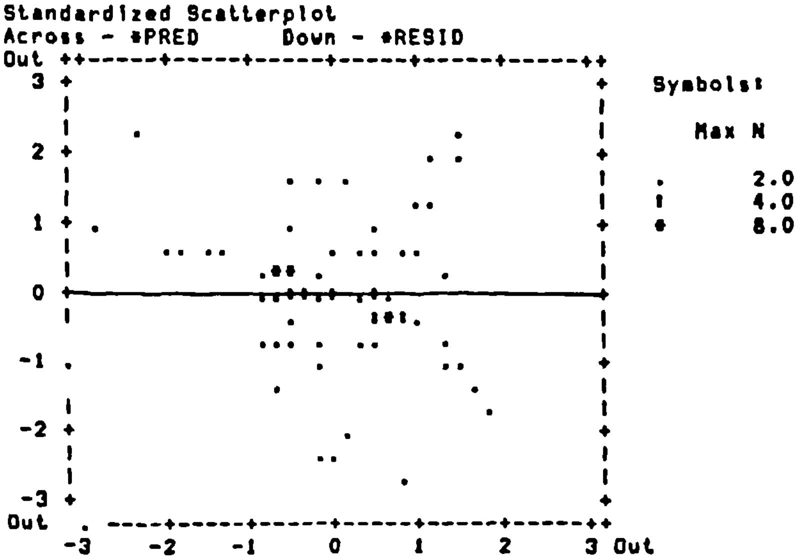


(q) SPS - QA relationship

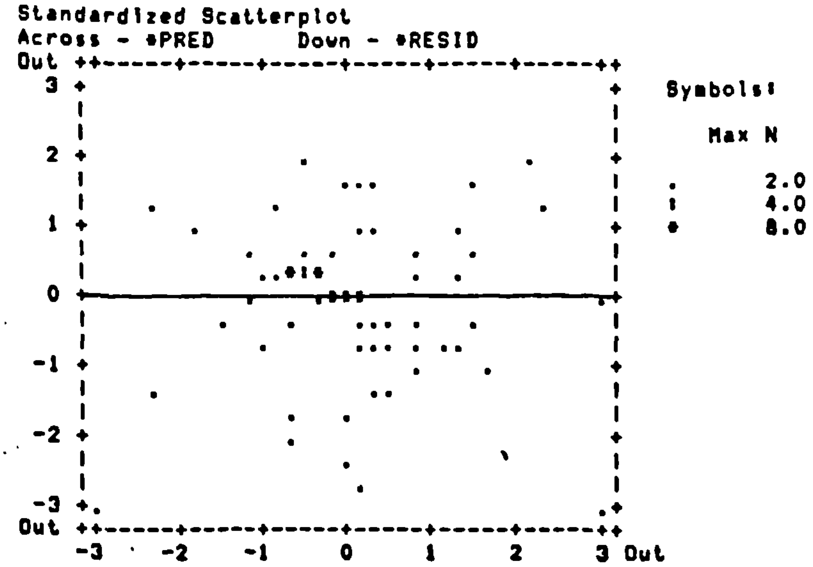
Standardized Scatterplot
Across - *PRED Down - *RESID



(r) SSR - QA relationship

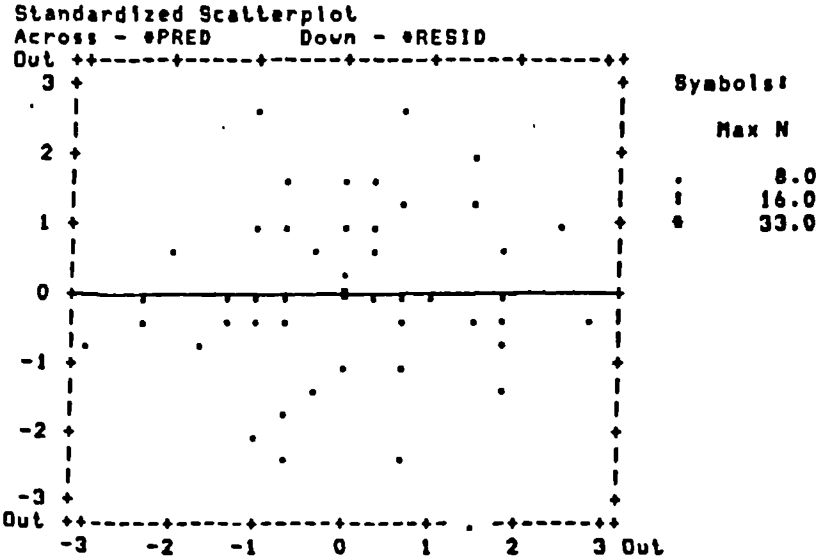


(s) SPT - QA relationship

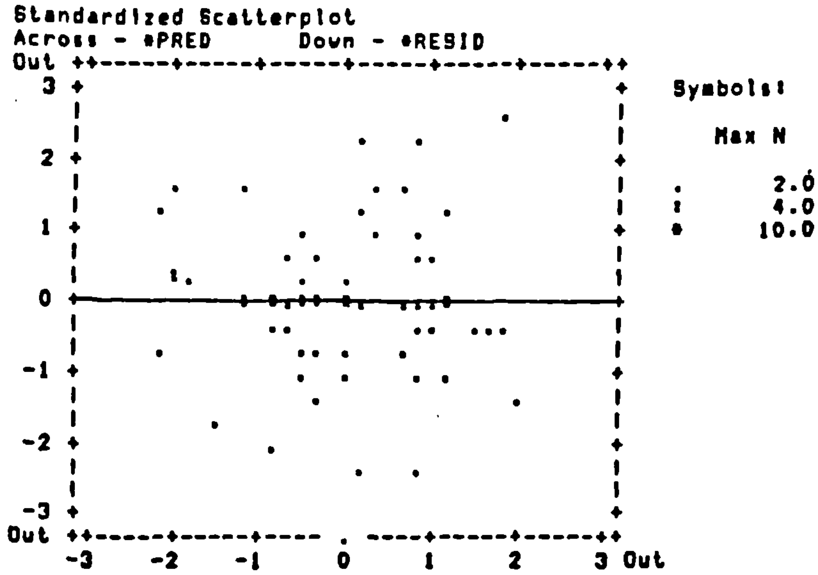


(t) SAT - QA relationship

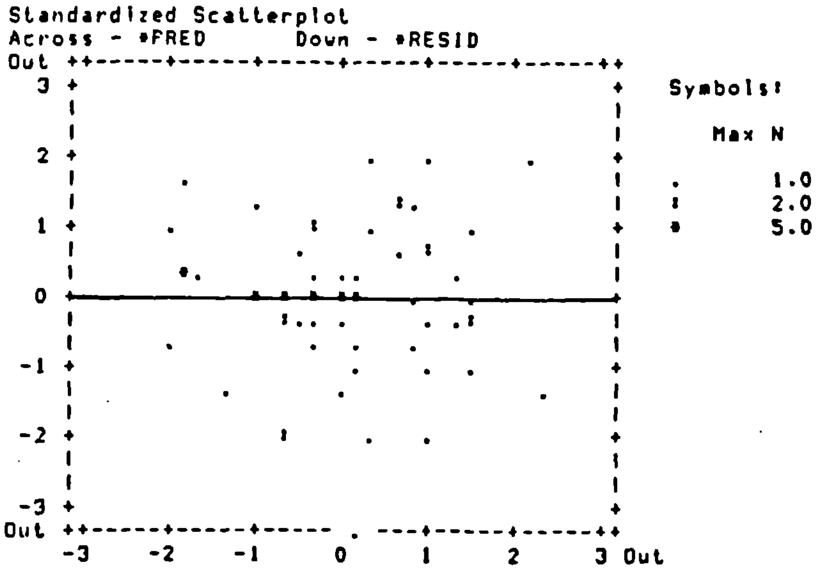
14-MAR-88 MULTIPLE REGRESSION 06
11:17:46 Heriot-Watt University DEC VAX-8800 VMS V4.5



(u) SKR, TID, TSG, AUT, FBC, DLC & BRI - QA relationship



(v) PSSI, OAC, KBR, INS, RAU & RCL - QA relationship



(w) IWM, SCW, SGS, SPS, SSR, SPT
& SAT - QA relationship

variable associated with a small increase in an independent variable depends on the level of another independent variable, an interactive model is called for [24]. The problem associated with non-additivity is that the accuracy of the predicted values of the dependent variables could be prejudiced. Lewis-Beck [188] has hinted tha the ascertainment of additivity of relationships may be attempted by testing for the absence of signficant interaction effects in the research data. This could be effected by the creation of appropriate multiplicative terms. Using such multiplicative terms in the regression equation could raise R^2 (coefficient of determination) and the incremental amount in R^2 is determined by the magnitude of the interaction effects [188].

The three multivariate regression equations for the interactive specification are as follows:

(1) $$QA = a + b_1 SKR + b_2 TID + b_3 TSG + b_4 AUT + b_5 FBC + b_6 DLC + b_7 BRI + e$$

(2) $$QA = a + b_1 PSSI + b_2 OAC + b_3 KBR + b_4 INS + b_5 RAU + b_6 RCL + e$$

(3) $$QA = a + b_1 IWM + b_2 SCW + b_3 SGS + b_4 SPS + b_5 SSR + b_6 SPT + b_7 SAT + e$$

where QA = Quality Achievement

a = intercept

$b_{1,2,3...i}$ = partial regression coefficients

SKR = Required Skill

TID = Task Identity

TSG = Task Significance

AUT = Job Autonomy

FBC = Feedback from the job

DLC = Dealing with Client & Others

BRI = Briefing Information

PSSI = Problem Solving through Support & Integration

OAC = Open Authentic Communication

KBR = Knowledge-Based Risk taking

INS = Initiating Structure

RAU = Role Strain

RCL = Role Clarity

IWM = Internal Work Motivation

SCW = Supervision - Control of Work

SGS = Supervision - Goal Setting

SPS = Supervision - Problem Solving

SSR = Supervision - Subordinate Relation

SPT = Supervision - Participation

SAT = Supervision Satisfaction

The independent variables in the above three equations will be tested for possible interaction effects. The first subgroup of the independent variables in equation one has 96 multiplicative terms representing all possible interaction effects among the seven independent variables. The set has 22 two-way, 9 three-way, 35 four-way, 22 five-way, 7 six-way and 1 seven way.

The second subgroup of the independent variables in equation two has 42 multiplicative terms representing all possible interaction effects among the six independent variables. the set has 15 two-way, 5 three-way, 15 four-way, 6 five-way and 1 six-way.

The third subgroup of the independent variables in equation three has 96 multiplicative terms representing all possible interaction effects among the seven independent variables. The set has 22 two-way, 9 three-way, 35 four-way, 22 five-way, 7 six-way and 1 seven-way.

Using the 'REGRESSION' procedure in SPSSX [257] with mean substitution of missing values, a set of the independent variables will be brought to the regression equation prior to the block of multiplicative terms for each of the above three regression equations.

The first regression equation has 7 independent variables, 1 dependent variable (QA) and 96 multiplicative terms. The regression subprogram will recognise the 7 independent variables, 1 dependent varaible and the 96 multiplicative terms as 104 individual variables. The total number of these variables clearly exceeded the program limitation of a maximum of 100 variables on any 'VARIABLES' list in SPSSX. This makes it impossible for the regression subprogram to be effective and hence the testing of the intended interaction effects cannot be undertaken, unfortunately, for the first subgroup of the independent variables.

For the second regression equation, a set of six independent variables was brought into the regression equation prior to the block of 42 multiplicative terms. It was readily clear from the computer printouts that only the 6 five-way and 1 six-way multiplicative terms were eventually included, the rest failed to exceed the tolerance index T with a default value of 0.001 and therefore not eligible for inclusion. A hierarchical F test recommended by Nie et al [222] will be conducted to determine whether the additional contribution to the explained variation in QA by the interaction effects alone is significant. The hierarchical F test is:

$$F = \frac{[(R^2 \text{ due to independent variables + Multiplicative terms}) - (R^2 \text{ due to independent variables})]/M}{(1-R^2 \text{ due to independent variables + multiplicative terms})/(N-K-1)}$$

Degree of freedom (df) are M and (N-K-1).

where R^2 = coefficient of multiple determination;

K = number of independent variables;

M = number of multiplicative variables, and

N = sample size.

The summary statistics for testing the null hypothesis that interaction effects are not significant are reported in Table 16. Inserting the relevant values into the above F test equation:-

$$F = \frac{(0.4823-0.3586)/11}{(1-0.4823)/(70-6-1)}$$

= 1.37; which is significant at 0.05 level, df 11 and 63.

Hence the null hypothesis is supported. The six independent variables in the second regression equation are relatively free from interaction effects.

The third regression equation mentioned earlier has 7 independent variables, 1 dependent variable (QA) and 96 multiplicative terms. Similar to regression one

Table 16 Summary Statistics for Testing Interactions Among PSSI, OAC, KBR, INS, RAU, RCL

Variable	Cumulative Multiple R	Cumulative R^2	R^2 Change
PSSI	0.3277	0.1074	0.1074
OAC	0.3948	0.1559	0.0484
KBR	0.4322	0.1868	0.1860
INS	0.5339	0.2850	0.2315
RAU	0.5740	0.3301	0.0102
RCL	0.5989	0.3586	0.1052
5 six-way multiplicative terms	0.6613	0.4373	0.1073
6 five-way multiplicative terms	0.6948	0.4823	0.0433

above, the SPSSX regression subprogram will recognise the specification as 104 individual variables. This makes it impossible for the regression subprogram to be effective, because the maximum number of 100 variables on any 'VARIABLE' list is exceeded. Hence the testing of the intended interaction effects for the third subprogram of the independent variables, regrettably cannot be undertaken.

In summary, the second subprogram of the independent variables (i.e. PSSI, OAC, KBR, INS, RAU and RCL) has been ascertained to be additive, whilst the first and third subgroups of the independent variables have not been possibly determined due to the reasons given above.

10.4.2.5 Zero Mean Value for the Error Term Disturbances

The assumption of zero mean disturbances involving the error term presumes that the summative outcome of all values (negative or positive) of disturbances to be zero. If this assumption is not met, the intercept estimate will be biased [188].

Nevertheless, since the intercept estimate is of secondary interest in the present research, this potential source of bias is rather unimportant. What is of importance to this research methodology concerns the estimation of partial regression coefficients and testing the proposed research hypotheses. The above assumption is therefore of no practical importance. Moreover, formal test for such an assumption is not apparently available [24]. From the foregoing and the standpoint of its substantive lack of practical significance as far as this research is concerned, verification of the above assumption would not be taken up here.

10.4.2.6 Heteroscedasticity of Error Term Disturbances

Heteroscedasticity refers to another non-random pattern in the residual error term. This assumption is known as the assumption of homoscedastic errors, and is a condition in which all disturbances have constant variance [24]. When this assumption is violated, the disturbances are said to be heteroscedastic, i.e. the variance varies with the values plotted on the horizontal axis [188]. The problem arises most frequently in the analysis of cross-sectional data. Though under such condition the parameter estimates still retain their statistical unbiasedness, but they are inefficient due to large variances.

Since such disturbances are not readily observable and their estimation often difficult, residual outcomes are usually accepted when the sample size is large enough [24]. Visual inspection of scatterplots of standardised residuals versus standardised predicted values of the variables concerned will facilitate in identifying heteroscedasticity. The shape of the scatterplot will indicate the presence or absence of heteroscedasticity [188].

In ideal situation, points within the plot should be distributed roughly within a horizontal band with the zero residual line as its central axis. This will indicate the absence of heteroscedasticity [24].

If heteroscedasticity is however suspected, a formal test for heteroscedasticity should be conducted [283]. Goldfield and Quandt [134] suggest a reasonable formal test for heteroscedasticity in which an independent variable is monotically related to the variance of the error term. The test assumes normal distribution of the disturbances and calls for the following procedures [24].

(i) one reorders the number of scores of the independent variables in order of increasing magnitude;

(ii) delete middle range scores from the sample, so that the number for deletion is equivalent to approximately a quarter of the sample size;

(iii) subdivide the remaining scores equally into two subsamples with low range scores forming the first subsample and the high range scores for the second subsample;

(iv) regress on the independent variable to derive the residual sum of squares (RSS) for each subsample;

(v) the required F test is:

$$F = \frac{(\text{RSS of 2nd subsample})/[(N-C)/2]-K}{(\text{RSS of 1st subsample})/[(N-C)/2]-K}$$

$$= \frac{\text{RSS of 2nd subsample}}{\text{RSS of 1st subsample}}$$

with $V_1 = V_2 = (N-C-2K)/2$ degrees of freedom (df)

where N = sample size;
C = number of middle scores deleted;
K = number of parameter estimates in each equation

Using the above test, one can determine the presence of heteroscedasticity. If the computed F statistic exceeds the tabulated value of F for the appropriate degrees of freedom at predetermined level of significance, the null hypothesis of homoscedasticity is rejected in favour of the alternative hypothesis of heteroscedasticity. The computed value of F will be used to indicate the severity of the problem. The higher it is from 1 the more likely that there is heteroscedasticity [188]. When it is confirmed that heteroscedasticity is the case using the above test, it is usual to transform the independent variables concerned so as to minimise variance inconsistency. Examination for signs of heteroscedasticity was undertaken of the scatterplots depicted in Figure 17 (used in assessing the linearity assumption). Heteroscedasticity is suspected for bivariate scatterplots (b), (i), (L), (o) and (s). Confirmation is therefore sought accordingly and the five relationships concerned were subjected to the Goldfield-Quandt test outlined earlier. The test results are tabulated in Table 17. It is clear from the table that TID-QA, OAC-QA, SCW-QA and SPT-QA relationships are homoscedastic. However, the RAU-QA relationship is heteroscedastic, as the determined value of *F is slightly greater than 1. Though, the value of the tabulated *F for RAU-QA relationship is greater than 1, it is generally assumed here that heteroscedasticity is not sufficiently severe to warrant concern. Bohrnstedt and Carter [35] have surveyed a number of studies of the severity of the consequences of heteroscedasticity on tests of statistical significance. They conclude that unless heteroscedasticity is "marked", significance tests are "virtually unaffected", and thus Ordinary Least Square

Table 17 Goldfeld-Quandt Test Results

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Scatterplot	Independent-Dependent Variables	RSS of 1st Subsample	RSS of 2nd Subsample	[(N-C)/2]-K	$*F = \frac{(4)/(5)}{(3)/(5)}$	Heteroscedasticity (*F > tabulated F) or Homoscedasticity (*F < tabulated F)
(b)	TID - QA	424.12	467.54	25	1.102	Homoscedasticity
(i)	OAC - QA	510.18	398.79	25	0.782	Homoscedasticity
(L)	RAU - QA	631.57	795.82	25	1.260	Heteroscedasticity
(0)	SCW - QA	352.82	401.79	25	1.139	Homoscedasticity
(S)	SPT - QA	289.76	312.98	25	1.080	Homoscedasticity

$N = 70$; $C = 16$; $K = 2$; df, $V_1 = V_2 = (N-C-2K)/2 = 25$; 0.05 level of significance

(OLS) estimation and the associated procedure for calculating standard errors can be used without concern of serious distortion.

Thus, it appears that heteroscedasticity is not sufficiently severe in this case to warrant concern, and no remedial action will be pursued here.

10.4.2.7 Normally Distributed Error Term Disturbances

This assumption states that the error term must be normally distributed. This assumption manifests itself in a normal symmetrical bell-shaped curve in which 95% of the disturbances are dispersed with $\pm$ 2 standard deviations of the zero mean [188]. The assumption is necessary only for tests of statistical significance; its violation will have no effect on the estimation of the parameters of the regression model [246]. It is quite fortunate that normality is not required for estimation, because it is often very difficult to defend this assumption in practice [24].

However, the 'REGRESSION=subcommand' facility as part of the 'REGRESSION' procedure in SPSSX [257] could be utilised to investigate the extent of compliance with normality assumption for the tests of statistical significance. To that effect, the above subcommand in the SPSSX [257] was activated to generate two sets of visual displays of standardised residuals. The first set consists of histograms of standardised residuals with a normal curve delineated in each case and the second set corresponding normal probability (p-p) plots of standardised residuals with the doted diagonal as the datum normality line in each case. The two sets of visual displays of standardised residuals are depicted in Figure 18. Examination of the histograms and the normal probability (p-p) plots does indicate very close approximation to normality for the QA-SKR, TID, TSG, AUT, FBC, DLC and BRI relationships. Very close approximation to normality is also depicted in the histograms and the p-p plots for the QA-PSSI, OAC, KBR, INS, RAU and RCL relationships. Deviation from normality is slightly indicated by the histogram and p-p plot depicting QA-IWM, SCW, SGS, SPS, SSR, SPT and SAT relationships.

There is some disagreement in the statistical literature over how serious the violations of normality actually is. Lewis-Beck [188] has asserted that normality assumptions is fairly robust and may be safely overlooked without serious effects when the sample size ($n > 40$) is large enough, for then the central-limit theorem can be invoked. The central-limit theorem indicates that the distribution of a sum of independent variables, which we can conceive of the error term as representing approaches normality as

Figure 18: Histograms and Normal Probability (P-P) Plots of Standardised Residusuals (a) to (c)

```
16-MAR-88    MULTIPLE REGRESSION 06
15:13:44     Heriot-Watt University              DEC VAX-8800   VMS V4.5


Histogram - Standardized Residual

 N Exp N       (* = 1 Cases,     . : = Normal Curve)
 0   .05   Out
 0   .11  3.00
 1   .27  2.67 *
 0   .62  2.33 .
 3  1.28  2.00 :**
 1  2.34  1.67 *.
 2  3.84  1.33 ** .
 6  5.65  1.00 *****:
 6  7.43   .67 ******.
15  8.77   .33 ********:******
 6  9.27   .00 ******   .
10  8.77  -.33 *********:*
 7  7.43  -.67 ******:
 5  5.65 -1.00 *****.
 3  3.84 -1.33 ***.
 3  2.34 -1.67 *:*
 0  1.28 -2.00 .
 2   .62 -2.33 :*
 0   .27 -2.67
 0   .11 -3.00
 0   .05   Out


Normal Probability (P-P) Plot
Standardized Residual
   1.0 +---------+---------+---------+---------*
       |                                   ****|
       |                                 **.   |
       |                               **.     |
       |                  .         ***.       |
   .75 +                           *  .        +
       |                          *.           |
 O     |                         .             |
 b     |                       .**             |
 s     |                     .**               |
 e .5  +                   ***                 +
 r     |                 **                    |
 v     |              ***                      |
 e     |             *                         |
 d     |          ***                          |
   .25 +         *                             +
       |       .*                              |
       |    ****                               |
       |   *                                   |
       |***                                    |
       +---------+---------+---------+---------+ Expected
               .25        .5       .75       1.0
```

(a) SKR, TID, TSG, AUT, FBC, DLC & BRI - QA relationship

```
Histogram - Standardized Residual

 N Exp N       (* = 1 Cases,      . : = Normal Curve)
 0   .05   Out
 0   .11  3.00
 0   .27  2.67
 0   .62  2.33 .
 1  1.28  2.00 :
 5  2.34  1.67 *:***
 1  3.84  1.33 *  .
 3  5.65  1.00 ***   .
11  7.43   .67 ******:****
10  8.77   .33 *********:*
12  9.27   .00 ***********:***
 6  8.77  -.33 ******   .
12  7.43  -.67 ******:******
 2  5.65 -1.00 **     .
 2  3.84 -1.33 ** .
 2  2.34 -1.67 *:
 0  1.28 -2.00 .
 2   .62 -2.33 :*
 1   .27 -2.67 *
 0   .11 -3.00
 0   .05   Out
```

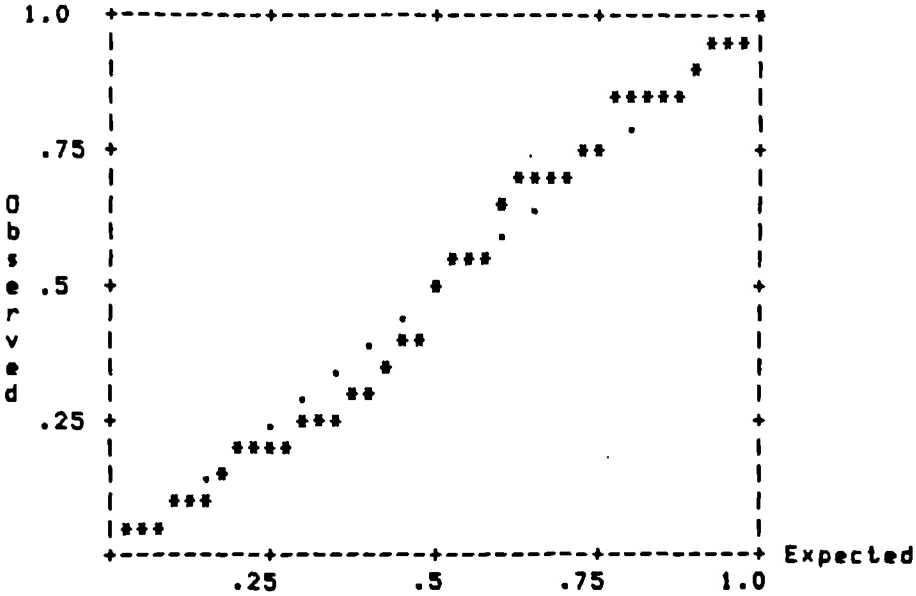
```
Normal Probability (P-P) Plot
Standardized Residual
   1.0  +---------+---------+---------+--------**
        |                                     * |
        |                                 ****  |
        |                              ***.     |
        |                             *  .      |
   .75  +                            *.         +
        |                           *           |
 O      |                         **            |
 b      |                       **              |
 s      |                     **                |
 e .5   +                   **                  +
 r      |                 .*                    |
 v      |               .**                     |
 e      |             .**                       |
 d      |           ***                         |
   .25  +         .*                            +
        |       . *                             |
        |     . **                              |
        |  *****                                |
        |**                                     |
        +---------+---------+---------+---------+ Expected
                 .25        .5       .75      1.0
```

(b) PSSI, OAC, KBR, INS, RAU & RCL - QA relationship

```
Histogram - Standardized Residual

 N Exp N        (* = 1 Cases,      . : = Normal Curve)
 0   .05   Out
 0   .11  3.00
 0   .27  2.67
 1   .62  2.33 :
 1  1.28  2.00 :
 1  2.34  1.67 *.
 6  3.84  1.33 ***:**
 1  5.65  1.00 *     .
10  7.43   .67 ******:***
10  8.77   .33 ********:*
15  9.27   .00 ********:******
 9  8.77  -.33 ********:
 3  7.43  -.67 ***      .
 5  5.65 -1.00 *****.
 3  3.84 -1.33 ***.
 1  2.34 -1.67 *.
 3  1.28 -2.00 :**
 0   .62 -2.33 .
 0   .27 -2.67
 0   .11 -3.00
 1   .05   Out *
```

Normal Probability (P-P) Plot
Standardized Residual



(c) IWM, SCW, SGS, SPS, SSR, SPT & SAT - QA relationship sample size ($n > 40$) increases, irrespective of the nature of the distribution in the population. Bohrnstedt and Carter [35] similarly have shown that regression analysis is quite robust against violations of normality and thus significance tests can be done in large samples ($n > 40$) even though this assumption cannot be justified substantively.

Taking the literature reviews and the particular incidence in this research into account, normality deviation is not sufficient enough to warrant concern.

10.4.2.8 Non-Autocorrelated Disturbances of the Error Term

Autocorrelation refers to the case in which the residual error terms from different observations in a chronological order of the same variable are correlated [246]. Autocorrelation and the problems it presents are more related to the validity of the statistical tests of significance and the confidence intervals but less likely associated with parameter estimates. This problem is more restricted to longitudinal data situation, for instance time series data.

Autocorrelation can be caused by several factors, including omission of an important explanatory variable or the use of an incorrect functional form.

It may also simply be due to the tendency of effects to persist over time or for dependent variables to behave cyclically [246]. In view of the fact that this problem is more restricted to longitudinal data but less likely to data of a cross-sectional nature as is the case in this research study, the issue of autocorrelation is not so important here. Therefore no further discussion on autocorrelation will be taken up here.

10.4.2.9 Absence of Specification Errors

Specification error is actually a nice way of saying that the 'wrong' model has been estimated. Specifically, specification errors typify a situation in which one or more of the following cases are present:

(i) specifying the functional form of the relationship improperly;

(ii) omitting one or more relevant variables;

(iii) the inclusion of one or more impertinent variables.

Inappropriate functional form refers to the application of a linear regression on a set of data which is nonlinear; consequently, the parameter estimate will be biased. The issue of nonlinearity of data has already been discussed in Section 10.4.2.3 and it was concluded that the linearity assumption has been satisfied by the data. Therefore specification error with regard to functional form is not an issue for consideration here.

When an important independent variable is omitted from a regression equation, it is likely that the regression coefficients and parameter estimates will be biased. The condition which determines the precise impact is the presence or absence of correlation between the omitted independent variable and other independent variable(s) in the regression equation. In the presence of correlation, bias and inconsistency are introduced into the parameter estimates as noted earlier. Whilst the absence of correlation means that the only parameter susceptible to adverse influence is the intercept estimate.

If a variable is included in the regression equation but is not in fact relevant, the estimates of the coefficients will be unbiased. However, if the irrelevant variable is correlated with the included relevant variables, the size of the estimated standard errors of coefficients of the relevant variables will increase [246]. This in turn means that the ratios will be smaller than if the correct specification were used. Hence, it is more likely to conclude that the coefficient on a relevant variable is not significantly different from zero. Nevertheless, the situation does not warrant that every variable can be incorporated into the equation unless there is some guiding consideration from the theory.

It could be inferred from specification errors regarding (ii) and (iii) above that they are basically related to theory. The most important thing to recognise here is that, to a substantial degree, it cannot be dealt with at the level of data analysis. Specification error to that regard is at heart a question of whether the regression equation corresponds to the process being modelled and estimated. This means that the theory under consideration should be the guiding principle. Regarding the present research study, considerations on the time involved, the nature of the building process, the nature of field data and its collection, implied that there is a probability of mis-specification. Moreover, the methodological approach undertaken in this study, in which the examination of the influences of many uncontrollable factors on the achievement of quality of work in construction as part of the objectives, implied that it is not possible to take every aspect of work into measurement operation. However, whether mis-specification has occurred or not in reality is uncertain and difficult to verify due to the absence of a reference model. The reference model may be defined as the 'correct' model, which takes all possible combination of factors into account. This is clearly impossible, for it cannot always be determined with absolute certainty as circumstances vary widely in practice and there is no list that could take into account every combination of factors that might be encountered. Given the circumstances, the best that could be done is to rely on the existing theory and experiential considerations during the model formation process, test the model, use the outcome results to revise both the theory and the model for further research.

10.4.2.10 Summary

At this point, it will be appropriate to summarise a number of issues discussed so far on the regression assumptions. The regression technique could provide a powerful method for analysing a wide range of behavioural and other related situations. At the same time, the technique relies on a set of assumptions that may or may not hold in different applications. In other words, it is not at all uncommon that one or more of the assumptions underlying regression are violated in typical applications.

There is some considerable disagreement in the statistical literature over how serious the violations of the regression assumptions actually are. At one extreme, researchers argue that regression analysis is 'robust', that is the parameter estimates are not meaningfully influenced by violations of the assumptions. This robust perspective on regression is employed in Kerlinger and Pedhazur [176], and Bohrnstedt and Carter [35]. At the other extreme, some feel that violations of the assumptions can bias the regression results. Bibby's [27] work provides an example of this 'fragile' view of regression analysis. It appears that both views may be right depending on the particular regression assumption involved.

Regarding the present research, the verification of regression assumptions are summarised as follows.

From the literature, there are various views expressed concerning the appropriate use of parametric statistics for the research variables, for this will not result in seriously biased estimates. Multicollinearity is probably present to a slight degree in the research data, but this does not constitute a problem. Linearity problem has not been suspected from the examination of the scatterplots of standardised residuals. Additivity of relationship has been ascertained for the second regression equation incorporating the independent variables PSSI, OAC, KBR, INS, RAU and RCL. Unfortunately this relationship could not be determined for the first and third subgroups of the independent variables in regression equations one and three due to reasons mentioned earlier. Furthermore, this should not be a great concern so long as the research is aimed at explanation of the phenomenon rather than for prediction purposes. Heteroscedasticity has not been sufficiently severe to warrant concern. A very slight deviation from normality by the QA-IWM, SCW, SGS, SPS, SSR, SPT and SAT relationships has not been sufficient to warrant attention. There is an unlikely problem of autocorrelation in the present research data because this type of problem is associated with longitudinal data. With regards specification errors pertaining to omission of vital variables and the inclusion of impertinent variables, there is probability of mis-specification. The most important thing to recognise about specification error is that, to a substantial degree, it cannot be dealt with at the level of data analysis.

Finally, it is concluded that the condition of the research data is such that they are appropriate for the application of multiple regression analysis for the forthcoming hypothesis testing.

CHAPTER 11

RESULTS

11.0 RESULTS

11.1 HYPOTHESIS TESTING

The hypothesis testing procedures relating to the criteria variable and the specified independent variables necessitate the translation of the research model into four separate linear regression equations incorporating standardised variables given as follows:-

(1) $$QA = a + b_1 SKR + b_2 TID + b_3 TSG + b_4 AUT + b_5 FBC + b_6 DLC + b_7 BIR + e$$

(2) $$QA = a + b_1 PSSI + b_2 OAC + b_3 KBR + b_4 INS + b_5 IWM + e$$

(3) $$QA = a + b_1 SCW + b_2 SGS + b_3 SPS + b_4 SSR + b_5 SPT + b_6 SAT + e$$

(4) $$QA = a + b_1 RAU + b_2 RCL + e$$

The 'REGRESSION' procedure is SPSSX [257] was invoked to generate the required statistics in each regression analysis. Forced entry for the variables named was adopted, where missing values were substituted by the variable mean, and the default statistical criteria (i.e. the probability of F-to-enter is 0.05, the probability of F-to-remove is 0.01; and tolerance is 0.01) and casewise plot produced thereafter. The statistical output from the regression analysis includes unstandardised and standardised coefficients. The former is symbolised by B and the latter by Beta. Other part of the statistical output, that will be reported later are: coefficient of multiple correlation, often denoted as R, coefficient of multiple determination, denoted as R^2, adjusted R^2, denoted R^2 and the standard error of the estimated regression coefficient.

To facilitate an understanding of how a decision is arrived at on whether support for a particular hypothesis is evident, it is necessary to explain the two criteria employed. They are:-

a) the computed sign of a standardised coefficient, and
b) the statistical significance of a standarised coefficient through the use of F statistic.

Before a hypothesis can be inferred to have the support of data, the presence of two elements is necessary.

The computed sign has to be consistent with the postulated influence, and the standardised coefficient has to be statistically significant through the use of F statistic, otherwise absence of one or both leads to the inference that the particular hypothesis lacks empirical support.

11.1.1 DETECTING OUTLIER

This section is concerned with checking for the probable existence of an outlier problem in the research data set prior to the actual task of hypothesis testing. The procedure involves directing attention to case analysis and the examination of the role each case plays in the regression. The task essentially, demands the identification of suspected outlying cases and estimation of the influence each outlying case has on the parameters and other aggregate statistics. Frequently, data sets contain one or more outliers, that is, points that appear separated in some way from the remainder of the data. In relation to the fitted regression equation, an outlier is the introduction of a bias into the parameter estimates, the coefficient of determination (R^2) and the standard error of estimate for the dependent variable.

As a general guideline on what to do with outliers Wetherill [283] offers the following:

1) Use some statistical technique to see how discrepant they are.
2) Carry out the analysis with and without the suspect observations, in order to see what effect that has.

For each regression equation, therefore, a casewise plot of studentised residuals is employed for the task of identifying possible outlying cases. Each suspected case is then tested to confirm that it is indeed an outlier. Weisberg [282] has proposed 'outlier test', where for the ith case of a suspected outlier, the test is given by:

$$t_i = r_i \left[\frac{n-p'-1}{n-p'-r_i} \right]^{0.5}$$

where t_i = student's t-test;

r_i = studentised residual;

n = sample size;

$p' = p+1$ (for a problem with an intercept term);

or

$p' = p$ (for a problem without an intercept term)

where p = number of predictors/independent variables

If the computed value of t_i exceeds the tabulated value in Table C (in the Appendix) at the predetermined level of significance, then the case concerned is indeed an outlier. However, outlier confirmation per se may not be sufficient to warrant removal of a case from the research data set. An additional factor is to be taken into account before a decision is made on its removal. Each case's individual influence on the regression needs to be assessed and the generally accepted measure of Cook's distance D which is one of the several case statistics output from the SPSSX. The magnitude of D provides an indication of the extent of influence the case has on the estimation of parameters and other aggregate statistics. When the value of D exceeds 1, the case is considered as bad fit in the regression equation. To summarise, when a case is outlier confirmed using the above test coupled with a value of D greater than 1, that case is a possible candidate for removal.

Accordingly, four casewise plots of standardised residuals and related case statistics were generated from the regression equations (1) to (4) mentioned earlier and presented in Figure 19. In each figure are case statistics comprising seven columns of values pertaining to each case. The full text for each abbreviation preceded by an asterisk is given as follows:

*PRED = Unstandardised predicted values;
*RESID = Unstandardised residuals;
*ZRESID = Standardised predicted values;
*SRESID = Studentised residuals;
*MAHAL = Mahalanobis' distance; and
*COOKD = Cook's distance.

Figure 19: CASEWISE PLOTS OF STANDARDISED RESIDUALS (a) to (d)

(a) Dependent Variable: QA (plot for regression equation 1)

```
 9-MAY-88   MULTIPLE REGRESSION 07                                                    PAGE 15
11:14:17    Heriot-Watt University          DEC VAX-8800   VMS V4.5

Casewise Plot of Standardized Residual

*: Selected   M: Missing

          -3.0     0.0      3.0
Case #    O:........:........:O      QA    *PRED   *RESID  *ZRESID  *SRESID   *MAHAL  *COOK D
     1     .        . *      .     5.92   5.6189    .2977    .6989    .7255   3.9806    .0051
     2     .        .  *     .     5.42   5.0613    .3554    .8343    .9446  14.1891    .0314
     3     .        .    *   .     6.42   5.6929    .7239   1.6993   1.7891   5.7698    .0434
     4     .   *    .        .     4.83   5.4935   -.6601  -1.5496  -1.6805   9.3500    .0622
     5     .        .    *   .     5.83   5.1478    .6855   1.6091   1.6968   5.9619    .0403
     6     .        *        .     5.25   5.2149    .0351    .0824    .0885   8.1198    .0001
     7     .      * .        .     5.33   5.5840   -.2507   -.5884   -.6316   8.1294    .0076
     8     .      * .        .     4.92   5.1682   -.2515   -.5905   -.6426   9.7583    .0095
     9     .    *   .        .     4.58   5.1954   -.6121  -1.4368  -1.4932   4.1249    .0223
    10     .       *.        .     5.25   5.4282   -.1782   -.4183   -.4663  12.4864    .0066
    11     .        . *      .     5.67   5.3519    .3148    .7389    .7707   4.6040    .0065
    12     .   *    .        .     5.08   5.7355   -.6522  -1.5310  -1.6357   7.5710    .0473
    13     .        . *      .     5.33   5.1199    .2135    .5011    .5293   6.1702    .0041
    14     .        .   *    .     5.92   5.2828    .6339   1.4879   1.5657   5.7026    .0329
    15     .        .    *   .     5.92   5.2403    .6763   1.5876   1.9721  23.2960    .2640
    16     .      * .        .     5.17   5.4364   -.2698   -.6332   -.6550   3.5201    .0037
    17     .        .   *    .     6.17   5.6176    .5491   1.2888   1.3518   5.2947    .0229
    18     .       *.        .     5.08   5.2326   -.1492   -.3503   -.3676   5.3606    .0017
    19     .        .  *     .     5.67   5.2617    .4049    .9506   1.0009   5.7747    .0136
    20     .        *        .     5.58   5.5598    .0235    .0553    .0611  11.6367    .0001
    21     .        .*       .     5.67   5.5686    .0981    .2303    .2560  12.2161    .0019
    22     .        .   *    .     6.25   5.6602    .5898   1.3845   1.4753   7.2441    .0368
    23     .        .*       .     5.50   5.3315    .1685    .3955    .4280   9.0953    .0039
    24     .        . *      .     5.67   5.4418    .2249    .5279    .5543   5.4391    .0039
    25     .        .   *    .     5.75   5.2279    .5221   1.2255   1.2883   5.5856    .0218
    26     .        .    *   .     5.92   5.1414    .7753   1.8199   1.8830   3.5583    .0312
    27     .        .*       .     5.92   5.7064    .2103    .4937    .5290   7.9146    .0052
    28     .       *.        .     5.00   5.1161   -.1161   -.2725   -.2875   6.0237    .0012
    29     .     *  .        .     4.92   5.3937   -.4770  -1.1198  -1.1861   6.5099    .0214
    30     .        .*       .     5.42   5.2611    .1556    .3652    .3867   6.4812    .0023
    31     .        .*       .     5.25   5.0684    .1816    .4263    .4565   7.8419    .0038
    32     .        *        .     5.25   5.1856    .0644    .1511    .1645   9.7947    .0006
    33     .        .   *    .     6.00   5.4827    .5173   1.2143   1.3601  13.0124    .0588
    34     .     *  .        .     5.08   5.4522   -.3689   -.8659   -.9294   8.1156    .0164
    35     .        *        .     5.67   5.6805   -.0138   -.0324   -.0340   5.2970    .0000
    36     .      * .        .     5.08   5.3517   -.2683   -.6299   -.7174  14.8245    .0191
    37     .     *  .        .     5.17   5.5574   -.3908   -.9172   -.9569   4.6192    .0101
Case #    O:........:........:O      QA    *PRED   *RESID  *ZRESID  *SRESID   *MAHAL  *COOK D
          -3.0     0.0      3.0
```

Casewise Plot of Standardized Residual

*: Selected   M: Missing

```
       -3.0       0.0       3.0
Case #  0:........:........:0      QA    *PRED   *RESID  *ZRESID  *SRESID   *MAHAL  *COOK D
   38   .         .*        .    5.25   5.0969    .1531    .3593    .3786   5.8615    .0020
   39   .  *      .         .    4.42   5.3800   -.9633  -2.2613  -2.3263   2.8155    .0394
   40   .         .*        .    5.25   5.1183    .1317    .3092    .3300   7.4235    .0019
   41   .         *         .    5.17   5.1373    .0294    .0690    .0713   3.3897    .0000
   42   .      *  .         .    4.92   5.3401   -.4234   -.9940  -1.0527   6.4958    .0168
   43   .         .*        .    5.33   5.1719    .1614    .3789    .4093   8.8834    .0035
   44   .    *    .         .    4.42   5.1532   -.7365  -1.7290  -1.8483   7.6378    .0610
   45   .        *.         .    4.75   4.9157   -.1657   -.3889   -.4207   9.0535    .0038
   46   .         . *       .    5.58   5.3018    .2815    .6608    .7315  11.7076    .0151
   47   .       * .         .    5.17   5.4087   -.2421   -.5682   -.5868   3.3009    .0029
   48   .         *         .    5.42   5.3519    .0648    .1521    .1560   2.4891    .0002
   49   .         *         .    5.25   5.3113   -.0613   -.1439   -.1534   7.3173    .0004
   50   .         *         .    5.25   5.1986    .0514    .1206    .1271   5.9318    .0002
   51   .   *     .         .    4.42   5.3239   -.9072  -2.1296  -2.2540   6.4203    .0764
   52   .       * .         .    4.92   5.2213   -.3046   -.7151   -.7681   8.2186    .0114
   53   .         *         .    5.30   5.3040    .0000    .0000    .0000    .0000    .0000
   54   .        *.         .    5.30   5.4225   -.1185   -.2781   -.2817    .7267    .0003
   55   .        *.         .    5.30   5.4225   -.1185   -.2781   -.2817    .7267    .0003
   56   .         *         .    5.30   5.3040    .0000    .0000    .0000    .0000    .0000
   57   .        *.         .    5.30   5.3857   -.0816   -.1916   -.1935    .3450    .0001
   58   .        *.         .    5.30   5.5146   -.2106   -.4944   -.5066   2.2960    .0016
   59   .        *.         .    5.30   5.4778   -.1738   -.4079   -.4156   1.5629    .0008
   60   .         *         .    5.30   5.3040    .0000    .0000    .0000    .0000    .0000
   61   .        *.         .    5.30   5.5146   -.2106   -.4944   -.5066   2.2960    .0016
   62   .         . *       .    5.30   4.9759    .3281    .7703    .8217   7.3749    .0116
   63   .         .*        .    5.30   5.1277    .1763    .4139    .4219   1.6091    .0009
   64   .         . *       .    5.30   5.0908    .2132    .5004    .5129   2.3520    .0017
   65   . *       .         .    3.67   4.7960  -1.1294  -2.6511  -2.9786  13.3560    .2910
   66   .         *         .    5.30   5.2403    .0637    .1496    .1715  15.5281    .0012
   67   .         . *       .    5.30   4.9707    .3333    .7824    .8338   7.2643    .0118
   68   .         .  *      .    5.30   4.9111    .3929    .9223   1.0553  15.3081    .0430
   69   .       * .         .    4.42   4.7408   -.3241   -.7608   -.8798  16.4209    .0326
   70   .         *         .    5.30   5.2761    .0279    .0654    .0682   4.5131    .0001
Case #  0:........:........:0      QA    *PRED   *RESID  *ZRESID  *SRESID   *MAHAL  *COOK D
       -3.0       0.0       3.0
```

(b) Dependent Variable: QA (plot for regression equation 2)

In the following Casewise Plot
when values are missing, the substituted mean is printed.

Casewise Plot of Standardized Residual

***: Selected   M: Missing**

```
        -3.0      0.0      3.0
Case #  O:........:........:O     QA    *PRED      *RESID   *ZRESID   *SRESID    *MAHAL   *COOK D
     1  .         .  *      .   6.00   5.5181       .4819     .9469     .9762    3.0971     .0100
     2  .         .*        .   6.00   5.7882       .2118     .4161     .4298    3.3494     .0021
     3  .         . *       .   6.00   5.6209       .3791     .7449     .7582    1.4014     .0034
     4  .         *         .   5.50   5.4273       .0727     .1428     .1535    8.3164     .0006
     5  .         .*        .   5.50   5.3394       .1606     .3155     .3235    2.4052     .0009
     6  .         .  *      .   6.00   5.4920       .5080     .9982    1.0417    4.6569     .0161
     7  .       * .         .   5.50   5.7584      -.2584    -.5077    -.5391    6.8127     .0062
     8  .        *.         .   5.25   5.4949      -.2449    -.4812    -.4933    2.3510     .0021
     9  .         . *       .   6.25   5.8435       .4065     .7987     .8421    5.9402     .0132
    10  .         . *       .   6.00   5.7115       .2885     .5668     .5755    1.0729     .0017
    11  .         . *       .   6.00   5.7127       .2873     .5646     .5967    6.2470     .0069
    12  .         .     *   .   6.75   5.6798      1.0702    2.1028    2.1352    1.0947     .0236
    13  .         .*        .   6.00   5.7913       .2087     .4101     .4333    6.2065     .0036
    14  .         . *       .   6.25   5.8772       .3728     .7325     .7577    3.5193     .0067
    15  .       * .         .   5.50   5.7723      -.2723    -.5351    -.5499    2.6783     .0028
    16  .         .*        .   5.50   5.2873       .2127     .4179     .4330    3.7357     .0023
    17  .        *.         .   5.50   5.6043      -.1043    -.2049    -.2142    4.8717     .0007
    18  .        *.         .   5.50   5.7383      -.2383    -.4682    -.5073    9.2349     .0075
    19  .         . *       .   6.50   6.1158       .3842     .7550     .8089    7.9106     .0161
    20  .         *         .   5.75   5.7454  4.5580E-03     .0090     .0093    4.6123     .0000
    21  .       * .         .   5.00   5.3661      -.3661    -.7194    -.7364    2.1652     .0043
    22  .         .    *    .   6.25   5.3955       .8545    1.6789    1.7416    3.8899     .0384
    23  .         *         .   5.50   5.5791      -.0791    -.1555    -.1585    1.6647     .0002
    24  .        *.         .   5.75   5.8675      -.1175    -.2309    -.2409    4.5901     .0009
    25  .         .*        .   6.00   5.8916       .1084     .2131     .2208    3.7553     .0006
    26  .        *.         .   6.00   6.0890      -.0890    -.1748    -.1845    6.0216     .0006
    27  .         .    *    .   6.00   5.2358       .7642    1.5015    1.5497    3.2410     .0261
    28  .         *         .   5.50   5.4519       .0481     .0945     .1011    7.8122     .0002
    29  .   *     .         .   4.50   5.6022     -1.1022   -2.1657   -2.2399    3.5095     .0583
    30  .         . *       .   5.75   5.3654       .3846     .7556     .7749    2.4116     .0052
    31  .       * .         .   5.00   5.2644      -.2644    -.5195    -.5381    3.7043     .0035
    32  .      *  .         .   5.00   5.5674      -.5674   -1.1149   -1.1461    2.7281     .0125
    33  .         *         .   5.50   5.5266      -.0266    -.0523    -.0538    2.6689     .0000
    34  .        *.         .   5.75   5.9329      -.1829    -.3594    -.3767    5.1889     .0023
    35  .         *         .   5.50   5.5300      -.0300    -.0589    -.0607    3.1502     .0000
    36  .        *.         .   5.25   5.4521      -.2021    -.3970    -.4224    7.0555     .0039
    37  .     *   .         .   4.50   5.1575      -.6575   -1.2918   -1.3361    3.5119     .0207
Case #  O:........:........:O     QA    *PRED      *RESID   *ZRESID   *SRESID    *MAHAL   *COOK D
        -3.0      0.0      3.0
```

Casewise Plot of Standardized Residual

*: Selected   M: Missing

```
        -3.0      0.0      3.0
Case #  O:........:........:O     QA     *PRED      *RESID    *ZRESID   *SRESID    *MAHAL   *COOK D
   38   .      *  .         .   4.75    5.2838      -.5338   -1.0489   -1.0776    2.6407     .0107
   39   .     *   .         .   4.75    5.5094      -.7594   -1.4921   -1.5123     .8408     .0104
   40   .         *         .   5.25    5.2693      -.0193    -.0379    -.0391    3.2066     .0000
   41   .         .  *      .   5.75    5.3142       .4358     .8564     .9197    8.1852     .0216
   42   .       * .         .   5.50    5.9104      -.4104    -.8063    -.8802   10.1126     .0248
   43   .        *.         .   5.50    5.6765      -.1765    -.3469    -.3510     .6043     .0005
   44   . *       .         .   4.00    5.2890     -1.2890   -2.5328   -2.6512    5.0442     .1122
   45   .         *         .   5.50    5.4867       .0133     .0262     .0266    1.3511     .0000
   46   .         .  *      .   6.25    5.7493       .5007     .9839    1.0078    2.2525     .0083
   47   .         . *       .   6.00    5.6060       .3940     .7743     .8059    4.3317     .0090
   48   .         . *       .   6.00    5.5766       .4234     .8320     .9552   15.6643     .0484
   49   .         .   *     .   6.25    5.5653       .6847    1.3454    1.4254    6.5400     .0415
   50   .    *    .         .   5.00    5.7710      -.7710   -1.5149   -1.5635    3.2364     .0266
   51   .         . *       .   5.50    5.1083       .3917     .7696     .9013   17.7130     .0503
   52   .         .*        .   6.25    6.1015       .1485     .2918     .3079    6.0187     .0018
   53   .         . *       .   5.54    5.2799       .2640     .5187     .5458    5.6904     .0053
   54   .         .*        .   5.54    5.3168       .2270     .4461     .4639    4.2080     .0029
   55   .         .*        .   5.54    5.3723       .1716     .3371     .3457    2.4031     .0010
   56   .         . *       .   5.54    5.2429       .3010     .5914     .6309    7.3961     .0092
   57   .         *         .   5.54    5.5439 -2.2204E-16     .0000     .0000     .0000     .0000
   58   .         *         .   5.54    5.5439 -2.2204E-16     .0000     .0000     .0000     .0000
   59   .         .*        .   5.54    5.3538       .1900     .3734     .3845    2.9489     .0015
   60   .         .*        .   5.54    5.3168       .2270     .4461     .4639    4.2080     .0029
   61   .         . *       .   5.54    5.2799       .2640     .5187     .5458    5.6904     .0053
   62   .         .*        .   5.50    5.3598       .1402     .2754     .3176   16.1143     .0055
   63   .    *    .         .   4.50    5.2968      -.7968   -1.5655   -1.6369    4.9007     .0417
   64   .    *    .         .   4.50    5.4094      -.9094   -1.7868   -1.8287    2.1427     .0265
   65   *         .         .   3.75    5.4296     -1.6796   -3.3001   -3.4825    6.0508     .2295
   66   .         *         .   5.54    5.5111       .0327     .0643     .0656    1.6246     .0000
   67   .         .*        .   5.54    5.4158       .1280     .2516     .2943   17.5998     .0053
   68   .         . *       .   5.54    5.1929       .3510     .6896     .7343    7.1606     .0120
   69   .     *   .         .   5.50    6.0955      -.5955   -1.1700   -1.2506    7.6147     .0371
   70   .         .*        .   5.54    5.2984       .2455     .4824     .5045    4.9213     .0040
Case #  O:........:........:O     QA     *PRED      *RESID    *ZRESID   *SRESID    *MAHAL   *COOK D
        -3.0      0.0      3.0
```

(c) Dependent Variable: QA (plot for regression equation 3)

```
 9-MAY-88   MULTIPLE REGRESSION 07                                                  PAGE 16
12:01:39    Heriot-Watt University        DEC VAX-8800   VMS V4.5

In the following Casewise Plot
when values are missing,  the substituted mean is printed.

Casewise Plot of Standardized Residual

*: Selected   M: Missing

          -3.0      0.0      3.0
  Case #   O:........:........:O      QA     *PRED     *RESID   *ZRESID   *SRESID    *MAHAL   *COOK D
       1   .        .*       .      6.00   5.8783      .1217     .2606     .2666    2.0845     .0004
       2   .        . *      .      6.00   5.7585      .2415     .5172     .5331    3.0752     .0022
       3   .        .   *    .      6.00   5.3803      .6197    1.3273    1.4365    9.1077     .0442
       4   .     *  .        .      5.50   6.0254     -.5254   -1.1254   -1.1910    6.4041     .0213
       5   .       *.        .      5.50   5.6419     -.1419    -.3040    -.3125    2.6953     .0007
       6   .        . *      .      6.00   5.6567      .3433     .7352     .7606    3.5501     .0051
       7   .        *        .      5.50   5.4588      .0412     .0883     .0917    4.0242     .0001
       8   .     *  .        .      5.25   5.7203     -.4703   -1.0072   -1.1193   12.1389     .0368
       9   .        .    *   .      6.25   5.4733      .7767    1.6634    1.6924    1.3576     .0126
      10   .        . *      .      6.00   5.7294      .2706     .5797     .5950    2.5177     .0024
      11   .        *        .      6.00   5.9399      .0601     .1288     .1330    3.2722     .0001
      12   .        .    *   .      6.75   5.9765      .7735    1.6566    1.7088    3.1658     .0234
      13   .        . *      .      6.00   5.7117      .2883     .6175     .6498    5.7074     .0057
      14   .        . *      .      6.25   5.9871      .2629     .5630     .5779    2.5126     .0022
      15   .    *   .        .      5.50   6.0662     -.5662   -1.2127   -1.2739    5.4885     .0210
      16   .        *        .      5.50   5.5502     -.0502    -.1075    -.1137    6.2817     .0002
      17   .      * .        .      5.50   5.8683     -.3683    -.7887    -.8333    6.1954     .0101
      18   .        *        .      5.50   5.4949 5.1185E-03     .0110     .0127   16.7087     .0000
      19   .        .   *    .      6.50   5.9352      .5648    1.2097    1.2820    6.5789     .0253
      20   .        .*       .      5.75   5.5943      .1557     .3334     .3508    5.6574     .0016
      21   .    *   .        .      5.00   5.6337     -.6337   -1.3573   -1.4404    6.7486     .0327
      22   .        . *      .      6.25   5.9360      .3140     .6724     .6985    4.0738     .0048
      23   .        *        .      5.50   5.5489     -.0489    -.1048    -.1070    1.8609     .0001
      24   .        .*       .      5.75   5.5728      .1772     .3795     .3994    5.7341     .0022
      25   .        .   *    .      6.00   5.4146      .5854    1.2537    1.4380   15.5634     .0816
      26   .        .   *    .      6.00   5.4096      .5904    1.2646    1.4020   11.8730     .0563
      27   .        .   *    .      6.00   5.3976      .6024    1.2901    1.3290    2.9912     .0135
      28   .        . *      .      5.50   5.1542      .3458     .7407     .8069    9.8661     .0152
      29   .      * .        .      4.50   4.8147     -.3147    -.6741    -.7487   12.0872     .0164
      30   .        .  *     .      5.75   5.3053      .4447     .9525     .9959    4.8888     .0115
      31   .    *   .        .      5.00   5.5868     -.5868   -1.2568   -1.3723   10.1369     .0452
      32   .      * .        .      5.00   5.2794     -.2794    -.5985    -.6367    7.0531     .0067
      33   .        .  *     .      5.50   4.9915      .5085    1.0891    1.1917   10.3820     .0350
      34   .       *.        .      5.75   5.9055     -.1555    -.3330    -.3465    4.2867     .0012
      35   .        .*       .      5.50   5.3684      .1316     .2818     .2966    5.7276     .0012
      36   .      * .        .      5.25   5.5202     -.2702    -.5786    -.6414   11.8618     .0118
      37   .   *    .        .      4.50   5.3710     -.8710   -1.8656   -1.9880    7.2501     .0670
  Case #   O:........:........:O      QA     *PRED     *RESID   *ZRESID   *SRESID    *MAHAL   *COOK D
```

Casewise Plot of Standardized Residual

*: Selected   M: Missing

```
          -3.0      0.0       3.0
Case #    O:........:.........:O     QA     *PRED      *RESID    *ZRESID   *SRESID    *MAHAL   *COOK D
   38     .     *   .         .     4.75   5.4495      -.6995    -1.4982   -1.5659    4.8463     .0283
   39     .      *  .         .     4.75   5.2206      -.4706    -1.0078   -1.0685    6.6225     .0177
   40     .       * .         .     5.25   5.5550      -.3050     -.6532    -.6734    3.1006     .0036
   41     .         *         .     5.75   5.6724       .0776      .1662     .1697    1.8401     .0002
   42     .       * .         .     5.50   5.7349      -.2349     -.5032    -.5140    1.8897     .0014
   43     .        *.         .     5.50   5.6142      -.1142     -.2447    -.2491    1.4554     .0003
   44     .    *    .         .     4.00   4.8078      -.8078    -1.7302   -1.9496   13.6701     .1281
   45     .       * .         .     5.50   5.8655      -.3655     -.7829    -.8327    7.0280     .0114
   46     .         .   *     .     6.25   5.6654       .5846     1.2521    1.3172    5.6663     .0231
   47     .         .  *      .     6.00   5.6042       .3958      .8478     .8944    6.0243     .0113
   48     .         . *       .     6.00   5.7387       .2613      .5596     .5796    3.6877     .0031
   49     .         .  *      .     6.25   5.7417       .5083     1.0887    1.1178    2.5564     .0085
   50     .        *.         .     5.00   5.2308      -.2308     -.4944    -.5167    4.8313     .0031
   51     .     *   .         .     5.50   6.1076      -.6076    -1.3014   -1.3985    8.2657     .0379
   52     .         .*        .     6.25   6.1041       .1459      .3124     .3333    7.4059     .0019
   53     .         *         .     5.54   5.4804       .0635      .1359     .1415    4.3071     .0002
   54     .        *.         .     5.54   5.7216      -.1777     -.3807    -.4028    6.3838     .0024
   55     .         *         .     5.54   5.6111      -.0672     -.1439    -.1537    7.5271     .0004
   56     .         . *       .     5.54   5.2606       .2833      .6067     .6478    7.4885     .0073
   57     .         . *       .     5.54   5.1679       .3760      .8053     .8625    7.8671     .0137
   58     .         *         .     5.54   5.5492 -5.3096E-03     -.0114    -.0121    7.2923     .0000
   59     .         .*        .     5.54   5.3355       .2083      .4462     .4692    5.6180     .0029
   60     .         .*        .     5.54   5.4166       .1273      .2726     .2923    8.0025     .0016
   61     .         .*        .     5.54   5.3294       .2145      .4594     .4948    8.5280     .0049
   62     .         .   *     .     5.50   4.8262       .6738     1.4432    1.5413    7.5160     .0417
   63     .   *     .         .     4.50   5.3958      -.8958    -1.9186   -2.0751    9.0313     .0914
   64     .        *.         .     4.50   4.6748      -.1748     -.3745    -.4976   28.9407     .0237
   65     . *       .         .     3.75   4.9863     -1.2363    -2.6479   -3.0759   16.8783     .4131
   66     .         .  *      .     5.54   5.0771       .4667      .9996    1.0776    8.6383     .0235
   67     .       * .         .     5.54   5.9322      -.3883     -.8317    -.9620   16.4417     .0391
   68     .         *         .     5.54   5.5718      -.0279     -.0598    -.0620    3.8381     .0000
   69     .       * .         .     5.50   5.8306      -.3306     -.7080    -.7316    3.3922     .0045
   70     .        *.         .     5.54   5.7330      -.1892     -.4052    -.4257    5.5095     .0024
Case #    O:........:.........:O     QA     *PRED      *RESID    *ZRESID   *SRESID    *MAHAL   *COOK D
          -3.0      0.0       3.0
```

(d) Dependent Variable: QA (plot for regression equation 4)

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 9-MAY-88    MULTIPLE REGRESSION 07                                              PAGE 12
11:25:50     Heriot-Watt University          DEC VAX-8800    VMS V4.5

In the following Casewise Plot
when values are missing,  the substituted mean is printed.

Casewise Plot of Standardized Residual

*: Selected    M: Missing

          -3.0      0.0      3.0
 Case #    O:........:........:O      QA     *PRED    *RESID   *ZRESID   *SRESID    *MAHAL   *COOK D
     1     .         .  *      .    4.75    4.3260     .4240     .5160     .5236    1.0100     .0027
     2     .     *   .         .    4.25    5.2399    -.9899   -1.2048   -1.2427    3.1637     .0329
     3     .         .    *    .    6.75    5.4955    1.2545    1.5268    1.6114    6.0725     .0986
     4     .        *.         .    5.25    5.5691    -.3191    -.3884    -.4162    7.9445     .0086
     5     .         .   *     .    6.00    4.8102    1.1898    1.4481    1.4650     .5964     .0168
     6     .         .  *      .    5.25    4.3804     .8696    1.0583    1.0710     .6395     .0092
     7     .         .    *    .    5.25    4.0166    1.2334    1.5012    1.5442    2.8077     .0462
     8     .         .     *   .    5.50    3.8423    1.6577    2.0174    2.0999    4.3246     .1225
     9     *         .         .    1.50    4.1094   -2.6094   -3.1758   -3.2488    2.0802     .1636
    10     .       * .         .    3.75    4.3804    -.6304    -.7672    -.7764     .6395     .0048
    11     .         .   *     .    5.00    3.8500    1.1500    1.3996    1.4554    4.2115     .0575
    12     .     *   .         .    3.75    4.7365    -.9865   -1.2006   -1.2107     .1506     .0082
    13     .         *         .    4.00    3.9506     .0494     .0601     .0620    3.2930     .0001
    14     .         . *       .    5.50    4.8915     .6085     .7406     .7518    1.0512     .0057
    15     .         .    *    .    6.25    4.9146    1.3354    1.6252    1.6428     .4839     .0196
    16     .         . *       .    5.50    5.0888     .4112     .5004     .5088    1.2650     .0029
    17     .         .   *     .    6.00    4.7794    1.2206    1.4856    1.5172    1.8625     .0330
    18     .        *.         .    4.75    5.0075    -.2575    -.3134    -.3174     .7450     .0009
    19     .         *         .    4.50    4.5508    -.0508    -.0618    -.0624     .3408     .0000
    20     .        *.         .    5.00    5.1817    -.1817    -.2211    -.2256    1.7059     .0007
    21     .         *         .    5.00    4.9261     .0739     .0899     .0908     .3721     .0001
    22     .         .  *      .    6.00    5.1158     .8842    1.0762    1.0927    1.0936     .0124
    23     .         .*        .    5.00    4.6436     .3564     .4337     .4374     .1912     .0011
    24     .        *.         .    4.75    5.0657    -.3157    -.3842    -.3926    1.9085     .0022
    25     .         .*        .    5.25    5.0580     .1920     .2337     .2393    2.2250     .0009
    26     .         . *       .    5.75    5.2669     .4831     .5880     .6028    2.3685     .0062
    27     .         .  *      .    4.75    3.9237     .8263    1.0057    1.0412    3.6442     .0260
    28     .        *.         .    5.00    5.2245    -.2245    -.2733    -.2835    3.8983     .0020
    29     .       * .         .    4.25    4.7404    -.4904    -.5968    -.6016     .1006     .0019
    30     .        *.         .    4.50    4.7481    -.2481    -.3019    -.3042     .0387     .0005
    31     .         *         .    4.75    4.7288     .0212     .0258     .0260     .2888     .0000
    32     .         . *       .    5.75    5.1586     .5914     .7198     .7374    2.2730     .0090
    33     .         . *       .    5.50    4.9805     .5195     .6322     .6433    1.3622     .0049
    34     .         .  *      .    5.50    4.5623     .9377    1.1412    1.1507     .1524     .0074
    35     .         *         .    4.50    4.5585    -.0585    -.0711    -.0718     .2025     .0000
    36     .     *   .         .    3.50    4.6744   -1.1744   -1.4293   -1.4401     .0456     .0105
    37     .        *.         .    4.00    4.3842    -.3842    -.4676    -.4731     .5894     .0017
 Case #    O:........:........:O      QA     *PRED    *RESID   *ZRESID   *SRESID    *MAHAL   *COOK D
          -3.0      0.0      3.0
```

```
Casewise Plot of Standardized Residual

*: Selected   M: Missing

        -3.0      0.0      3.0
Case #  O:........:........:O      QA    *PRED     *RESID   *ZRESID   *SRESID    *MAHAL   *COOK D
   38   .         . *       .    5.00   4.5739      .4261     .5186     .5227     .0787     .0014
   39   .     *   .         .    3.50   4.3804     -.8804   -1.0715   -1.0843     .6395     .0095
   40   .         *         .    4.50   4.5662     -.0662    -.0805    -.0812     .1151     .0000
   41   .     *   .         .    3.50   4.4733     -.9733   -1.1845   -1.1959     .3228     .0092
   42   .        *.         .    4.25   4.5623     -.3123    -.3801    -.3833     .1524     .0008
   43   .        *.         .    4.50   4.6629     -.1629    -.1982    -.1997     .0046     .0002
   44   .    *    .         .    3.25   4.3804    -1.1304   -1.3757   -1.3922     .6395     .0156
   45   .        *.         .    4.25   4.6590     -.4090    -.4978    -.5015     .0165     .0012
   46   .     *   .         .    3.50   4.4887     -.9887   -1.2033   -1.2142     .2499     .0090
   47   .         *         .    4.50   4.4035      .0965     .1175     .1188     .5300     .0001
   48   .      *  .         .    3.75   4.5700     -.8200    -.9980   -1.0059     .0905     .0053
   49   .         *         .    4.50   4.3881      .1119     .1362     .1377     .5521     .0001
   50   .         .  *      .    5.50   4.7635      .7365     .8964     .9033     .0679     .0042
   51   .     *   .         .    3.75   4.8179    -1.0679   -1.2996   -1.3130     .4073     .0118
   52   .    *    .         .    3.75   5.1097    -1.3597   -1.6548   -1.6801    1.0778     .0290
   53   .         . *       .    6.00   5.4286      .5714     .6955     .7631   10.7029     .0396
   54   .         .*        .    5.50   5.1307      .3693     .4495     .4736    5.8706     .0083
   55   .         *         .    4.25   4.3568     -.1068    -.1300    -.1328    1.8827     .0003
   56   .      *  .         .    4.00   4.8135     -.8135    -.9901   -1.0090    1.5700     .0131
   57   .   *     .         .    3.25   4.8251    -1.5751   -1.9169   -1.9631    2.2223     .0626
   58   .         *         .    4.50   4.4728      .0272     .0331     .0341    2.9525     .0000
   59   .       * .         .    3.75   4.3645     -.6145    -.7479    -.7659    2.2283     .0096
   60   .    *    .         .    3.25   4.6085    -1.3585   -1.6534   -1.6720     .5451     .0211
   61   .         *         .    4.50   4.3684      .1316     .1602     .1643    2.4201     .0005
   62   .         *         .    4.69   4.6885      .0000     .0000     .0000     .0000     .0000
   63   .         *         .    4.69   4.6885      .0000     .0000     .0000     .0000     .0000
   64   .         .  *      .    4.69   3.9523      .7362     .8960     .9251    3.2917     .0189
   65   .         *         .    4.75   4.7536 -3.5758E-03    -.0044    -.0044     .0258     .0000
   66   .         .  *      .    4.69   3.9523      .7362     .8960     .9251    3.2917     .0189
   67   .         .*        .    5.75   5.4632      .2868     .3490     .3997   15.4117     .0166
   68   .         *         .    4.69   4.6885      .0000     .0000     .0000     .0000     .0000
   69   .         .    *    .    6.50   5.2928     1.2072    1.4692    1.6839   15.4928     .2966
   70   .        *.         .    4.50   4.6629     -.1629    -.1982    -.1997     .0046     .0002
Case #  O:........:........:O      QA    *PRED     *RESID   *ZRESID   *SRESID    *MAHAL   *COOK D
        -3.0      0.0      3.0
```

An examination of Figure 19(a) to (d) seems to indicate that case 65 in Figure 19(b); case 65 in Figure 19(c) and case 9 in Figure 19(d) are suspected outliers because their studentised residuals exceed ± 3.0000 magnitude. Their respective studentised residuals are -3.4825, -3.0759 and -3.2488. Accordingly these three cases were subjected to the preceding Weisberg's [282] 'outlier test' for confirmation. The results of the outlier test is reported in Table 18. It is clear from the table that cases 65 in Figure 19(c) and 9 in Figure 19(d) are confirmed outliers. As indicated earlier the magnitude of Cook D provides an indication of the extent of influence a case has on the estimation of parameters and other aggregate statistics. The values of D for these cases - 65 and 9, are only 0.4131 and 0.1636 respectively and each is less than 1. Therefore these case are considered non-influential cases insofar as their impact on the regression is concerned. A decision is therefore take to keep the sample size against the removal of the aforementioned cases from the research data.

Table 18 Outlier Test Results

Case No	n	r_i	p'	$t_i=r_i\left[\frac{n-p'-1}{n-p'-r_i^2}\right]^{0.5}$	Tabulated value (α= 0.01)	Confirmed outlier?
65	70	-3.4825	5	-3.8307	4.05	No
65	70	-3.0759	7	-4.0838	4.05	Yes
9	70	-3.2488	2	-4.4183	4.03	Yes

11.1.2 DIRECT EXAMINATION OF RESIDUALS

Examining residuals is one of the most important tasks in any regression analysis. Residuals are conceived as measures of the error component. A residual analysis involves the careful inspection of the differences between the observed and predicted values of the response variable after a regression equation is fitted to the data. In doing so, one hopes to spot any anomalies in the data which might cause poor parameter estimation, whether the fit of the regression equation is 'good' or 'bad' or whether the proportion of explained variation is adequate. Nie et al [222] have indicated that an examination of residuals provides information relevant to two basic types of questions. First, it may indicate lack of linearity and provide guidance towards the most appropriate modifications. The regression assumption of linearity of relationships in which the dependent variable (QA) and the respective independent variables in bivariate regression models were analysed, has already been discussed in Section 10.4.2.3 of the thesis.

The second type of question which may be answered by examination of residuals is whether the assumptions about the errors are met [222]. The assumptions of the error components have also been discussed in Sections 10.4.2.5 to 10.4.2.8 of the thesis.

In this section of the thesis, analysis of residuals was undertaken for the multiple regression equation incorporating all the variables in order to indicate the suitability of the multivariate model before the forthcoming hypothesis testing. Whetherill [283] has noted that residual plots are mostly utilised for observing patterns in data. Hence one may plot residuals against fitted values and against values of the individual independent variables. Nie et al [222] indicated a similar view. They noted that since a direct examination of residuals involves a search for visible patterns, it is accomplished most readily when residuals are arrayed in a scatterplot.

Following the above recommendation it was decided to regress the dependent variable against all the independent variables in the study in order to indicate the suitability of the multivariate model as mentioned above. Therefore, the subcommand = 'SCATTERPLOT' in SPSSX [257] was invoked to request partial regression plots for the residual analysis. Partial regression plots are scatterplots of the residuals of the dependent variable against the residuals of the independent variable when both of these variables are regressed on the other independent variables. Figure 20 displays the partial regression plots produced as a result of the multivariate model. Examination of Figure 20 reveals that the residuals appear to be randomly distributed. However, slight deviation from random distribution is indicated in INS-QA, IWM-QA and RAU-QA relationships.

It is not inconceivable to encounter a situation in which there is one or more departure from the given set of regression assumptions, considering the nature of field data, such as the data in this study.

It is possible therefore that one or more violations of the regression assumptions could be encountered. However, the deviation noted in Figure 20 above is not sufficient enough to warrant concern. Moreover, the regression assumptions have been covered in various subsections of Section 10.4.2 in this thesis.

11.1.3 HYPOTHESIS A1

The Achievement of Perceived Quality (QA) on site is critically and positively influenced by high standards of design, such achievement is influenced by the following variables:

Figure 20: Partial regression plots for the multivariate model

12-Jul-88 MULTIPLE REGRESSION 07
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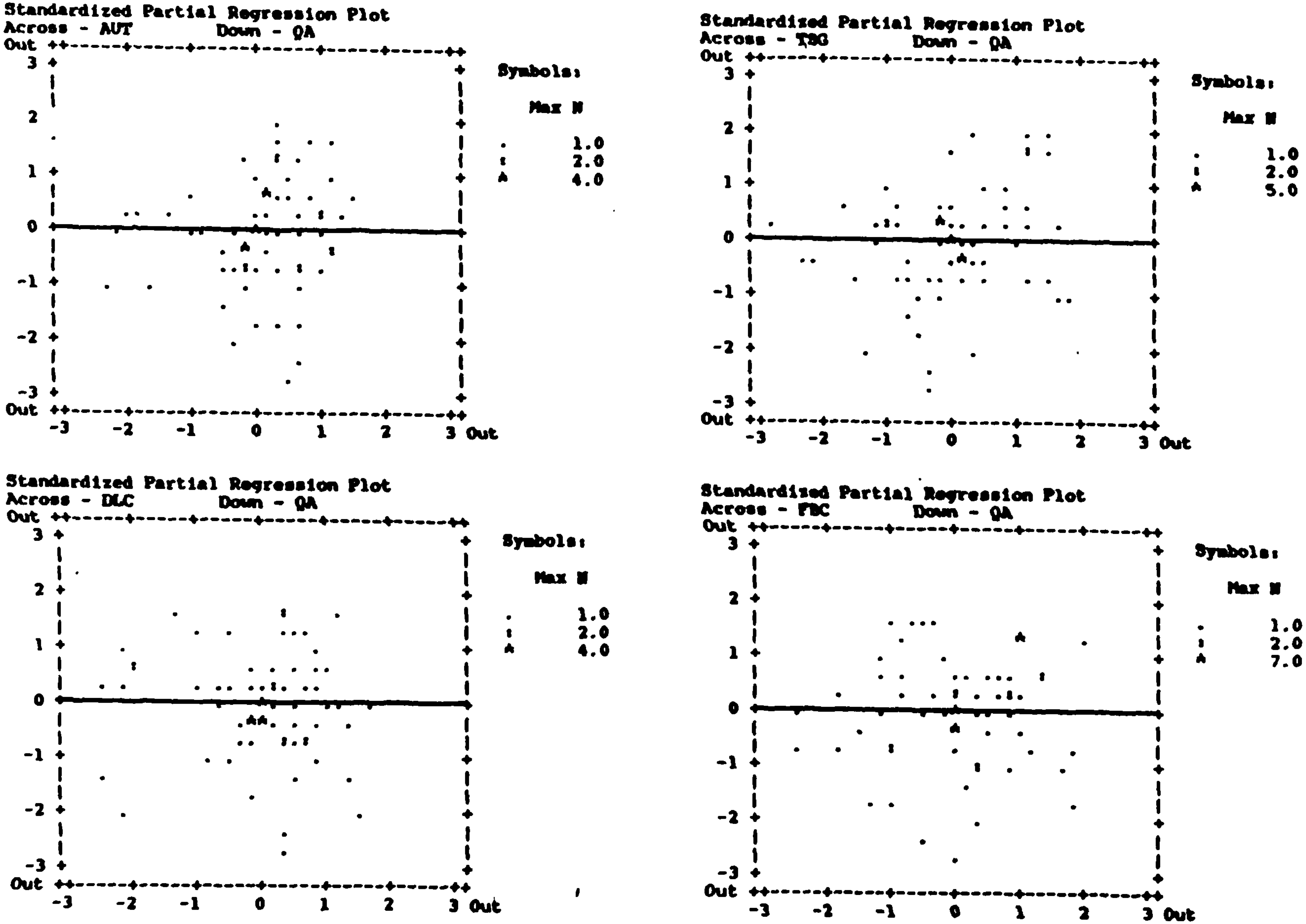
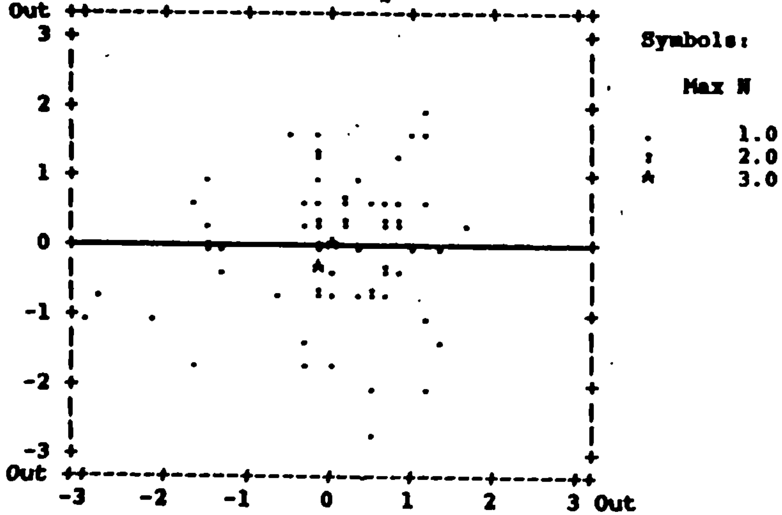
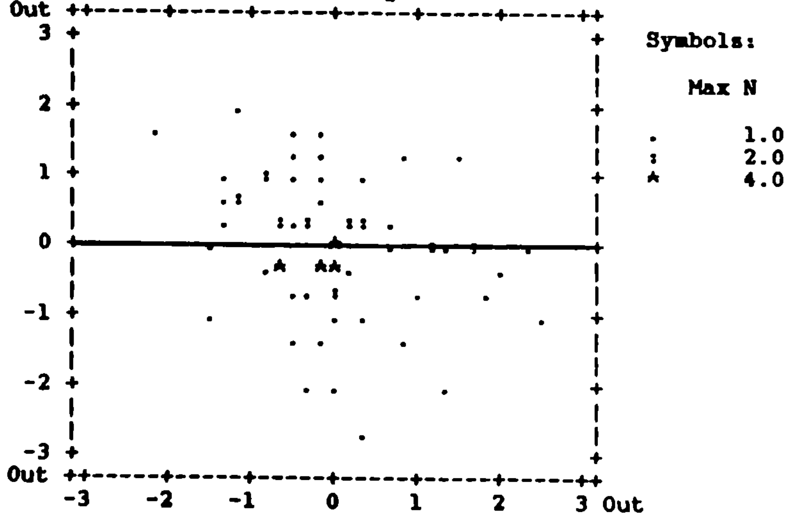


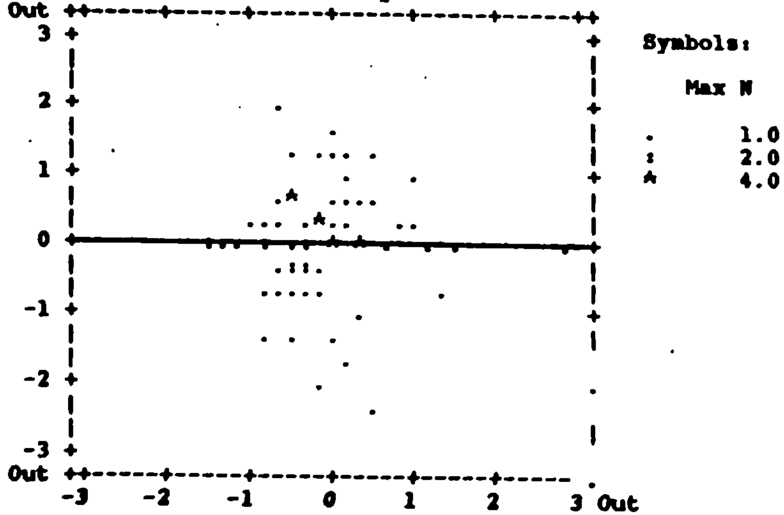
Standardized Partial Regression Plot
Across - TID Down - QA



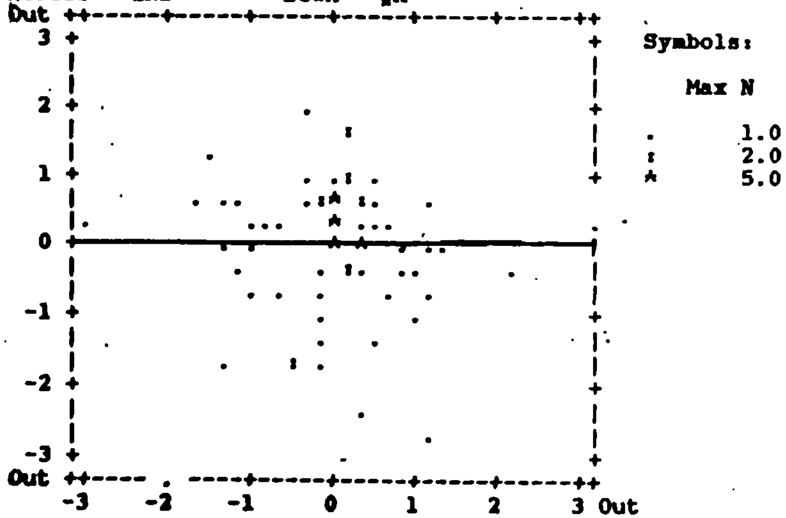
Standardized Partial Regression Plot
Across - SKR Down - QA



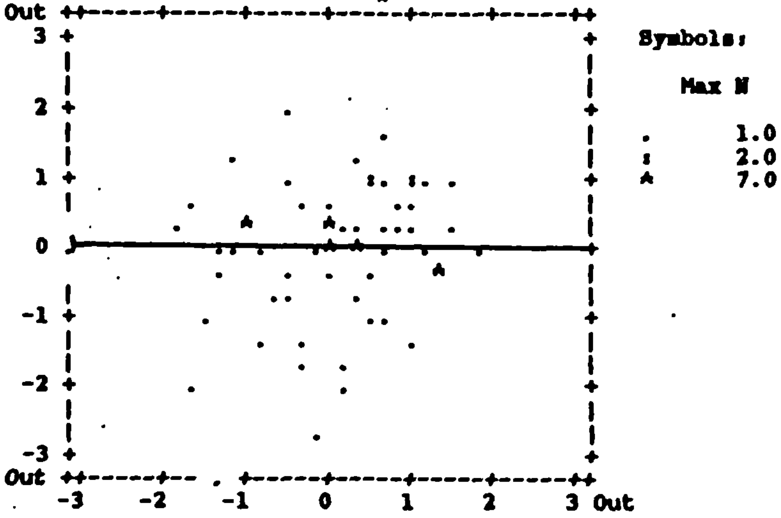
Standardized Partial Regression Plot
Across - BRI Down - QA



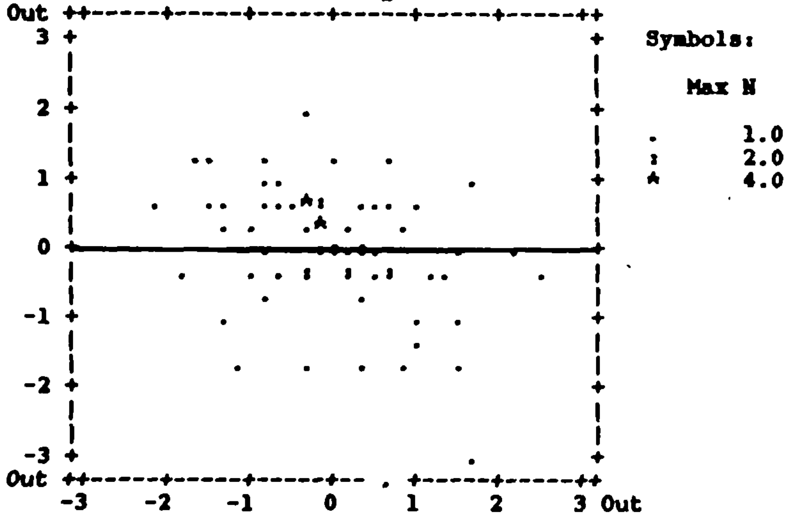
Standardized Partial Regression Plot
Across - INS Down - QA



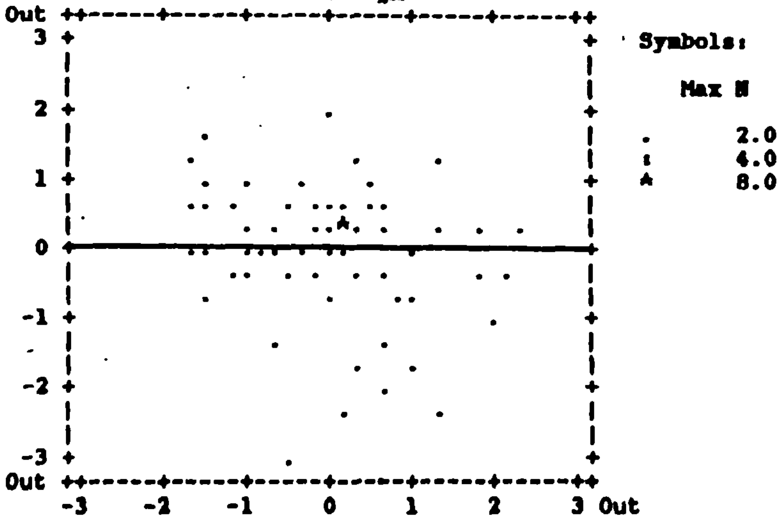
Standardized Partial Regression Plot
Across - PSSI Down - QA



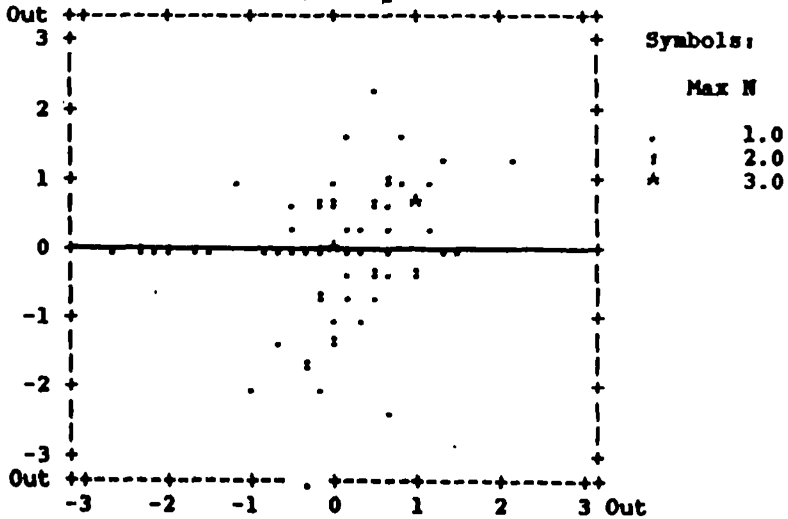
Standardized Partial Regression Plot
Across - OAC Down - QA



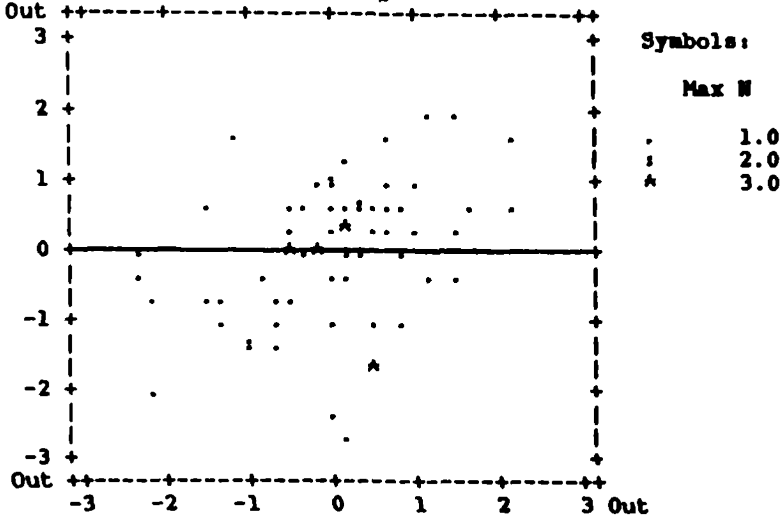
Standardized Partial Regression Plot
Across - KBR Down - QA



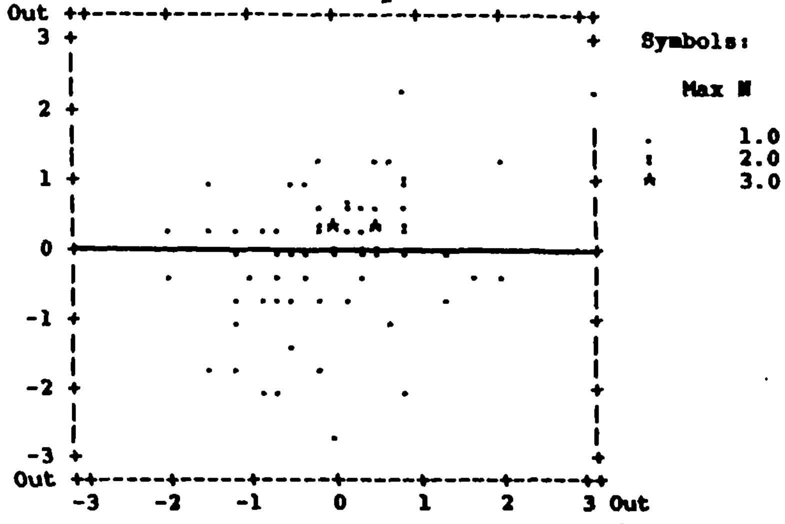
Standardized Partial Regression Plot
Across - IWM Down - QA



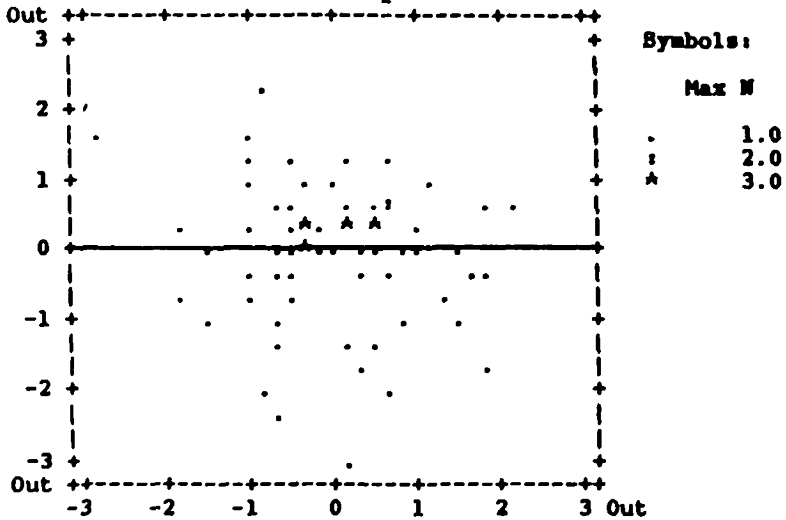
Standardized Partial Regression Plot
Across - SGS Down - QA



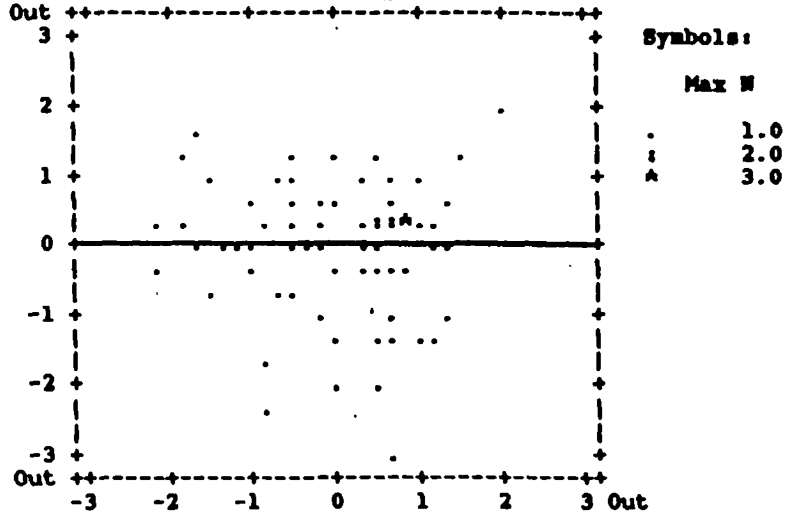
Standardized Partial Regression Plot
Across - SCW Down - QA



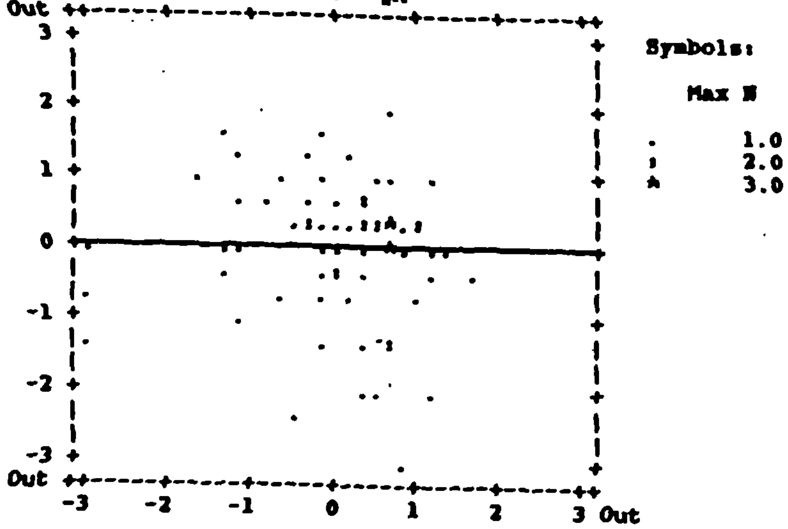
Standardized Partial Regression Plot
Across - SPS Down - QA



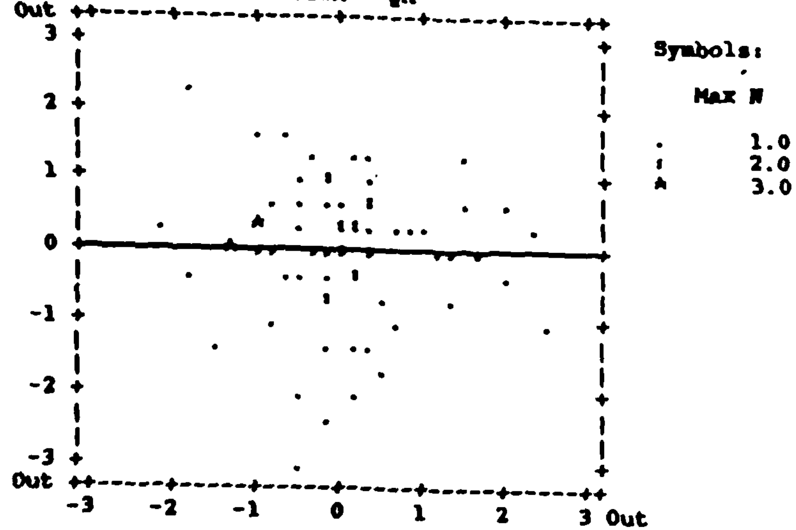
Standardized Partial Regression Plot
Across - SSR Down - QA



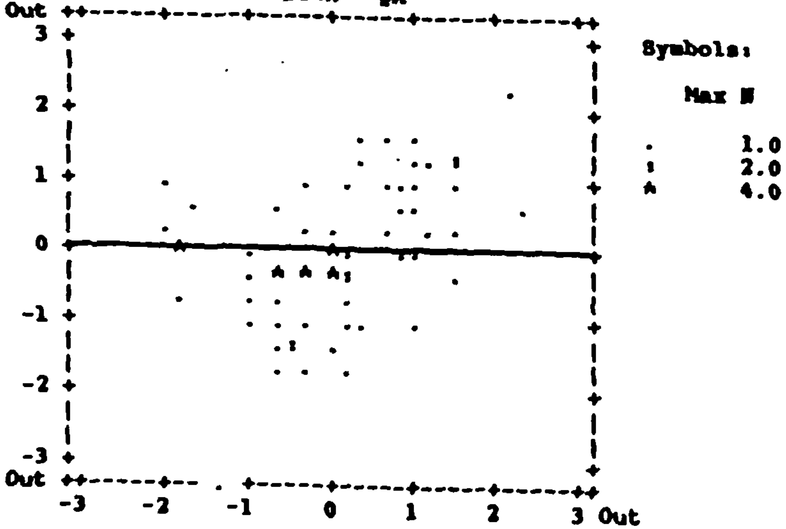
Standardized Partial Regression Plot
Across - SPT Down - QA



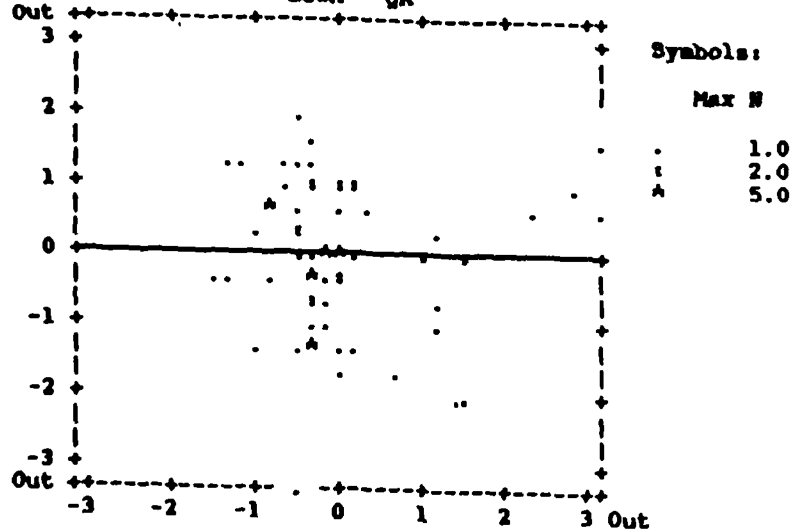
Standardized Partial Regression Plot
Across - SAT Down - QA



Standardized Partial Regression Plot
Across - RCL Down - QA



Standardized Partial Regression Plot
Across - RAU Down - QA



A1.1 Required Skill (SKR)

A1.2 Task Identity (TID)

A1.3 Task Significance (TSG)

A1.4 Job Autonomy (AUT)

A1.5 Feedback from the Job (FBC)

A1.6 Dealing with Client and Others (DLC)

A1.7 Briefing Information (BRI)

The first regression analysis involves regressing the QA variable on the variables SKR, TID, TSG, AUT, FBC, DLC and BRI to compute the standardised coefficients and other aggregate statistics. Pertinent regression statistics so computed are presented in Table 19. Intercorrelations, means and standard deviations are contained in Table 20. The derived regression equation is given hereby:

$$QA = 5.15 + 0.27SKR + 0.13TID + 0.23TSG + 0.02AUT + 0.03FBC + 0.12DLC + 0.32BRI$$

To test the overall statistical significance of the preceding regression equation, the computed F statistic is 7.35. With 7 and 62 degrees of freedom, the computed F statistic exceeds the tabulated F value. In other words, the equation attains statistical significance at the 0.05 level. The individual standardised coefficient for each of the independent variable is tested for statistical

Table 19 Selected Statistics for the Regression of QA on SKR, TID, TSG, AUT, FBC, DLC and BRI

Dependent Variable : QA (Quality Achievement)

Multiple R = 0.4718

R Square = 0.2226

Adjusted R Square = 0.1349

Standard Error = 0.4260

Degrees of Freedom = 7 and 62

F = 7.3470

Independent Variable	Unstandardised partial reg coef (B)	Standard error of B	Standardised partial reg coef (Beta)	F
SKR	0.13023	0.05616	0.27060	5.378
TID	0.15309	0.06954	0.12749	4.846
TSG	0.18906	0.07950	0.23243	5.655
AUT	-0.05126	0.06399	-0.02185	0.642
FBC	0.04345	0.06453	0.02557	0.453
DLC	0.09833	0.03742	0.11903	6.905
BRI	0.16583	0.06118	0.31624	7.347
Constant	5.15022	0.70426	-	53.479

Table 20 Intercorrelations, Means and Standard Deviations for QA, SKR, TID, TSG, AUT, FBC, DLC, and BRI

Variable	SKR	TID	TSG	AUT	FBC	DLC	BRI	QA
SKR	-							
TID	-0.108	-						
TSG	0.078	-0.076	-					
AUT	0.003	0.222	0.218	-				
FBC	0.109	0.215	0.175	0.344	-			
DLC	-0.241	0.032	0.366	0.249	-0.016	-		
BRI	-0.109	-0.262	0.127	-0.248	-0.168	-0.039	-	
QA	-0.150	0.107	0.253	0.311	0.275	-0.252	-0.549	-
Mean	4.214	5.543	5.912	5.944	5.483	5.811	27.192	5.232
Std Dev	1.101	1.324	0.825	1.105	1.011	1.304	8.385	1.104

significance using the F test and the results are reported in Table 21. It is clear from the table that all the standardised coefficients have reached statistical significance, except coefficients -0.02 and 0.03 regarding sub-hypothesis A1.4 and A1.5 respectively. The coefficient for A1.4 has a negative sign, suggesting negative influence from AUT to QA, a contradiction to postulation. In other words, the other standardised coefficients are significantly different from zero and that each of the variables SKR, TID, TSG, DLC and BRI contributes significantly to the regression after the remaining independent variables in the set have been taken into account. The coefficient of multiple determination, R^2 is 0.223, and measures the percentage of the variation in QA which is explained by variation in SKR, TID, TSG, AUT, FBC, DLC and BRI taken together. This indicates that 22.3 percent of variation in QA about its mean is explained by variation in the aforementioned variables about their respective means.

It appears hypothesis A1 is not totally consistent with the data. The discrepancy lies in standardised coefficients -0.02 and 0.03 associated with AUT and FBC; and their associated F statistics not reaching significant levels. Hence hypothesis A1 partially supported by data.

Table 21 Tests of Statistical Significance for the Standardised Coefficients Associated with Hypothesis A1

Hypothesis	Standardised Coefficient	Computed F Statistic	Significance
A1.1	0.27	5.378	Significant*
A1.2	0.13	4.846	Significant*
A1.3	0.23	5.655	Significant*
A1.4	-0.02	0.642	Not Significant*
A1.5	0.03	0.453	Not Significant*
A1.6	0.12	6.905	Significant*
A1.7	0.32	7.347	Significant*

* df 7 and 62; 0.05 level of significance

11.1.4 HYPOTHESES B1, B2 AND B3

Hypothesis B1

The Achievement of Perceived Quality (QA) on site is critically and positively influenced by team collaborative interpersonal relationship, such achievement is influenced by the following variables:

B1.1 Problem solving through support and integration (PSSI);

B1.2 Open authentic communication (OAC);

B1.3 Knowledge-based risk taking (KBR).

Hypothesis B2

The Achievement of Perceived Quality (QA) on site is critically and positively influenced by supervisor initiating structure (INS).

Hypothesis B3

The Achievement of Perceived Quality (QA) on site is critically and positively influenced by internal work motivation (IWM).

The second regression analysis demands the QA variable to be regressed on the variables PSSI, OAC, KBR, INS and IWM. Selected regression statistics are presented in Table 22. Intercorrelations, means and standard deviations for all the variables are tabulated in Table 23. The derived regression equation is given below:-

$$QA = 7.54 + 0.19PSSI + 0.36OAC + 0.24KBR - 0.01INS + 0.20IWM$$

In order to test the overall significance of the above regression equation, the F statistic is computed at 8.86 with 5 and 64 degrees of freedom. Since the computed F statistic exceeds the tabulated value of F, the regression equation is statistically significant at the 0.05 level.

The individual standardised coefficient for each of the independent variables is tested for statistical significance using the F test and the results are reported in Table 24. It is apparent from Table 24 that all the standardised coefficients have reached statistical significance except coefficient -0.01 associated with hypothesis B2. The negative sign of 0.01 coefficient for B2 is suggesting a negative influence from INS to QA, a contradiction to postulation. Stated differently, the other standard-

Table 22 Selected Statistics for the Regression of QA on PSSI, OAC, KBR, INS and IWM

Dependent Variable: QA (Quality Assurance)

Multiple R = 0.60134

R Square = 0.36161

Adjusted R Square = 0.35467

Standard Error = 2.30841

Degree of Freedom = 5 and 64

F = 8.86272

Independent Variable	Unstandardised partial reg coef (B)	Standard error of B	Standardised partial reg coef (Beta)	F
PSSI	0.22173	0.10127	0.19215	4.794
OAC	0.48813	0.16396	0.35989	8.863
KBR	0.39130	0.18444	0.24281	4.501
INS	-0.10989	0.18971	-0.01488	0.336
IWM	0.11093	0.04141	0.20406	7.176
Constant	7.53960	1.31845	-	32.702

Table 23 Intercorrelations, Means and Standard Deviations for QA, PSSI, OAC, KBR, INS and IWM

Variable	PSSI	OAC	KBR	INS	IWM	QA
PSSI	-					
OAC	0.327	-				
KBR	0.171	-0.057	-			
INS	-0.046	-0.107	-0.054	-		
IWM	-0.065	-0.250	0.105	0.367	-	
QA	0.375	-0.322	-0.208	-0.0104	0.363	-
Mean	4.023	3.992	3.291	40.784	4.941	5.232
Std Dev	0.594	0.613	0.475	4.936	0.991	1.104

Table 24 Tests of Statistical Significance for the Standardised Coefficients Associated with Hypotheses B1, B2 and B3

Hypothesis	Standardised Coefficient	Computed F Statistic	Significance
B1.1	0.19	4.794	Significant*
B1.2	0.36	8.863	Significant*
B1.3	0.24	4.501	Significant*
B2	-0.01	0.336	Not Significant*
B3	0.20	7.176	Significant*

* df 5 and 64; 0.05 level of significance

ised coefficients are significantly different from zero and that each of the variables PSSI, OAC, KBR and IWM contributes significantly to the regression after the remaining independent variables in the set have been taken into account. The coefficient of multiple determination, $R^2 = 0.362$, and measures the percentage of the variation on QA which is explained by variation in PSSI, OAC, KBR, INS and IWM taken together. This implies that 36.2 percent of variation in QA about its mean is explained by variation in the aforementioned independent variables about their respective means. The variance left unaccounted for by the preceding regression equation is 63.8%.

It is evident that hypotheses B1 and B3 are consistent with data. Hence these hypotheses are supported by the data. On the other hand, hypothesis B2 is not consistent with data, and therefore, it is not supported by the data.

11.1.5 HYPOTHESES B4 AND B5

Hypothesis B4

The Achievement of Perceived Quality (QA) on site is critically and positively influenced by high Work-Place-Supervision, such achievement is influenced by the following variables:

B4.1 Control of Work (SCW);

B4.2 Work Facilitation - goal setting (SGS);

B4.3 Work Facilitation - problem solving (SPS);

B4.4 Work Facilitation - subordinate relations (SSR);

B4.5 Participation (SPT)

<u>Hypothesis B5</u>

The Achievement of Perceived Quality (QA) on site is critically and positively influenced by Supervision Satisfaction (SAT).

The third regression equation necessitates the QA variable to be regressed on the variables SCW, SGS, SPS, SSR, SPT and SAT. Selected regression statistics are reported in Table 25. Inter- correlations, means and standard deviations for all the variables concerned are tabulated in Table 26.

The regression equation inferred is presented as follows:-

$$QA = 3.90 + 0.49SCW + 0.48SGS - 0.03SPS + 0.30SSR + 0.32SPT - 0.05SAT$$

Table 25 Selected Statistics for the Regression of QA on SCW, SGS, SPS, SSR, SPT and SAT

Dependent Variable: QA (Quality Achievement)				
Multiple R = 0.5909 R Square = 0.3491 Adjusted R Square = 0.2756 Standard Error = 0.46690 Degrees of Freedom = 6 and 63 F = 8.23753				
Independent Variable	Unstandardised partial reg coef (B)	Standard error of B	Standardised partial reg coef (Beta)	F
SCW	0.24930	0.09703	0.48875	6.601
SGS	0.25380	0.10506	0.47755	5.836
SPS	-0.02645	0.14132	-0.03206	0.035
SSR	0.26211	0.10732	0.30157	5.965
SPT	0.16108	0.05796	0.31664	7.724
SAT	-0.14416	0.15928	-0.05134	0.819
Constant	3.90473	0.54884	-	50.616

Table 26 Intercorrelations, Means and Standard Deviations for QA, SCW, SGS, SPS, SSR, SPT and SAT

Variable	SCW	SGS	SPS	SSR	SPT	SAT	QA
SCW	-						
SGS	0.430	-					
SPS	0.501	0.318	-				
SSR	0.350	0.527	0.500	-			
SPT	0.347	0.104	0.251	0.283	-		
SAT	0.371	0.257	0.299	0.397	0.116	-	
QA	0.218	0.468	0.269	0.335	0.285	0.109	-
Mean	5.103	5.375	5.172	4.761	4.704	3.812	5.232
Std Dev	1.034	0.763	0.963	0.772	1.044	0.604	1.104

For the foregoing regression equation, the computed F statistic is 8.24 with 6 and 63 degrees of freedom. Overall statistical significance is reached at the 0.05 level. Table 27 reports standardised co-efficients for each of the independent variables that will be tested for statistical significance using the F test individually for each variable. It is apparent from Table 27 that four of the standardised co-efficients have reached statistical significance. These are: 0.49, 0.48, 0.30, and 0.32 associated with hypotheses B4.1, B4.2, B4.4 and B4.5. The remaining two standardised coefficients fail to reach statistical significance and they are -0.03 and -0.05 associated with hypotheses B4.3 and B5 each having a coefficient with a negative sign, suggesting negative influence from SPS and SAT to QA; a contradiction to postulation.

The first four aforementioned standardised coefficients are significantly different from zero and that each of the variables SCW, SGS, SSR and SPT contributes significantly to the regression after the remaining independent variables in the set have been taken into account. The coefficient of multiple determination, $R^2 = 0.35$, and measures the percentage of the variation on QA which is explained by variation in SCW, SGS, SPS, SSR, SPT and SAT taken in combination. This indicates that 35 percent of

Table 27 Tests of Statistical Significance for the Standardised Coefficients Associated with Hypotheses B4 and B5

Hypothesis	Standardised Coefficient	Computed F Statistic	Significance
B4.1	0.49	6.601	Significant*
B4.2	0.48	5.836	Significant*
B4.3	-0.03	0.035	Not Significant*
B4.4	0.30	5.965	Significant*
B4.5	0.32	7.724	Significant*
B5	-0.05	0.819	Not Significant*

* df 6 and 63; 0.05 level of significance

variation in QA about its mean is explained by variation in the preceding independent variables about their respective means. The variance left unaccounted for by the aforementioned regression equation is 65%.

It is evident that hypothesis B4 is partially consistent with data, hence it is partially supported by data. Hypothesis B5 is not consistent with data, therefore not supported by data.

11.1.6 HYPOTHESES B6 AND B7

Hypothesis B6

The Achievement of Perceived Quality (QA) on site is critically and negatively influenced by Role Strain (RAU).

Hypothesis B7

The Achievement of Perceived Quality (QA) on site is critically and positively influenced by Role Clarity (RCL).

The fourth and final regression analysis concerns regressing the QA variable on the variables RAU and RCL in order to test the aforementioned hypotheses. Selected statistics for the regression are reported in

Table 28. Intercorrelations, means and standard deviations are presented in Table 29. The regression equation so derived is given as follows:-

QA = 2.98 - 0.25RAU + 0.45RCL

For the above regression equation, the computed F statistic is 16.83 with 2 and 67 degrees of freedom. Since the computed F statistic exceeds the tabulated value of F, the regression equation is statistically significant at 0.05 level.

Each of the two independent variables' standardised coefficients is tested for statistical significance using the F test and the results are reported in Table 30. It is clear from the table that the two standardised coefficients have reached statistical significance. In other words, the two standardised coefficients are significantly different from zero and that each of the variables RAU and RCL contributes to the regression. The computed R^2 = 0.203 which means 20.3% of the variance in QA is accounted by RAU and RCL leaving the unexplained variance at 79.7% the negative sign of standardised coefficient of Role Strain (RAU) variable is indicative of a negative influence of the RAU on QA as postulated. Hence, hypotheses B6 and B7 are supported by data.

Table 28 Selected Statistics for the Regression of QA on RAU and RCL

Dependent Variable: QA (Quality Assurance)

Multiple R = 0.4505

R Square = 0.2030

Adjusted R Square = 0.1792

Standard Error = 0.8217

Degrees of Freedom = 2 and 67

F = 16.82681

Independent Variable	Unstandardised partial reg coef (B)	Standard error of B	Standardised partial reg coef (Beta)	F
RAU	-0.20775	0.06840	-0.25319	9.225
RCL	0.35614	0.08682	0.44741	16.827
Constant	2.98378	0.51746	-	33.249

Table 29 Intercorrelations, Means and Standard Deviations for QA, RAU and RCL

Variable	RAU	RCL	QA
RAU	-		
RCL	0.357	-	
QA	0.345	0.560	-
Mean	2.734	4.175	5.232
Std Dev	0.603	1.213	1.104

Table 30 Tests of Statistical Significance for the Standardised Coefficients Associated with Hypotheses B6 and B7

Hypothesis	Standardised Coefficient	Computed F Statistic	Significance
B6	-0.25	9.225	Significant*
B7	0.45	16.827	Significant*

* df 2 and 67; 0.05 level of significance

11.2 SUMMARY OF RESEARCH RESULTS

It would be appropriate at this point to summarise the research results after the completion of hypothesis testing. The research results are collated in Table 31 for ease of reference. It is evident from Table 31 that main hypotheses B1, B3, B6 and B7 are supported by data, whereas main hypotheses A1 and B4 are partially supported by data. Hypotheses B2 and B5 are not supported by data. A summary of standardised regression weights of the independent variables on the dependent variable (QA) is depicted on Figure 21 for ease of reference.

With reference to main hypothesis A1, Job Autonomy, and Feedback from the Job dimensions of the nature of design core job characteristics do not contribute significantly to the regression in influencing the achievement of quality of work as postulated. Specifically, Job Autonomy variable imparts negative influence, though it fails to reach statistical significance. The remaining five core design dimensions - Required Skill, Task Identity, Task Significance, Dealing with Client and Others and Briefing Information - have significant positive influence on the achievement of quality as postulated.

Main hypothesis B1 is supported in that the Team Collaborative Interpersonal Relationship variables - Problem Solving through Support and Integration, Open

Table 31 Presentation of Research Results

Associated Variable	Hypothesis	Postulated sign of influence	Regression Coefficient	Significance of regression coefficient	Is influence as postulated?	Is hypothesis supported?
SKR	A1.1	+ve	0.27	Significant*	Yes	Yes
TIO	A1.2	+ve	0.13	Significant*	Yes	Yes
TSG	A1.3	+ve	0.23	Significant*	Yes	Yes
AUT	A1.4	+ve	-0.02	Not Significant*	No	No
FBC	A1.5	+ve	0.03	Not Significant*	Yes	No
DLC	A1.6	+ve	0.12	Significant*	Yes	Yes
BRI	A1.7	+ve	0.32	Significant*	Yes	Yes
PSSI	B1.1	+ve	0.19	Significant*	Yes	Yes
OAC	B1.2	+ve	0.36	Significant*	Yes	Yes
KBR	B1.3	+ve	0.24	Significant*	Yes	Yes
INS	B2	+ve	-0.01	Not Significant*	No	No
IWM	B3	+ve	0.20	Significant*	Yes	Yes
SCW	B4.1	+ve	0.49	Significant*	Yes	Yes
SGS	B4.2	+ve	0.48	Significant*	Yes	Yes
SPS	B4.3	+ve	-0.03	Not Significant*	No	No
SSR	B4.4	+ve	0.30	Significant*	Yes	Yes
SPT	B4.5	+ve	0.32	Significant*	Yes	Yes
SAT	B5	+ve	-0.05	Not Significant*	No	No
RAU	B6	-ve	-0.25	Significant*	Yes	Yes
RCL	B7	+ve	0.45	Significant*	Yes	Yes

* at 0.05 level of significance

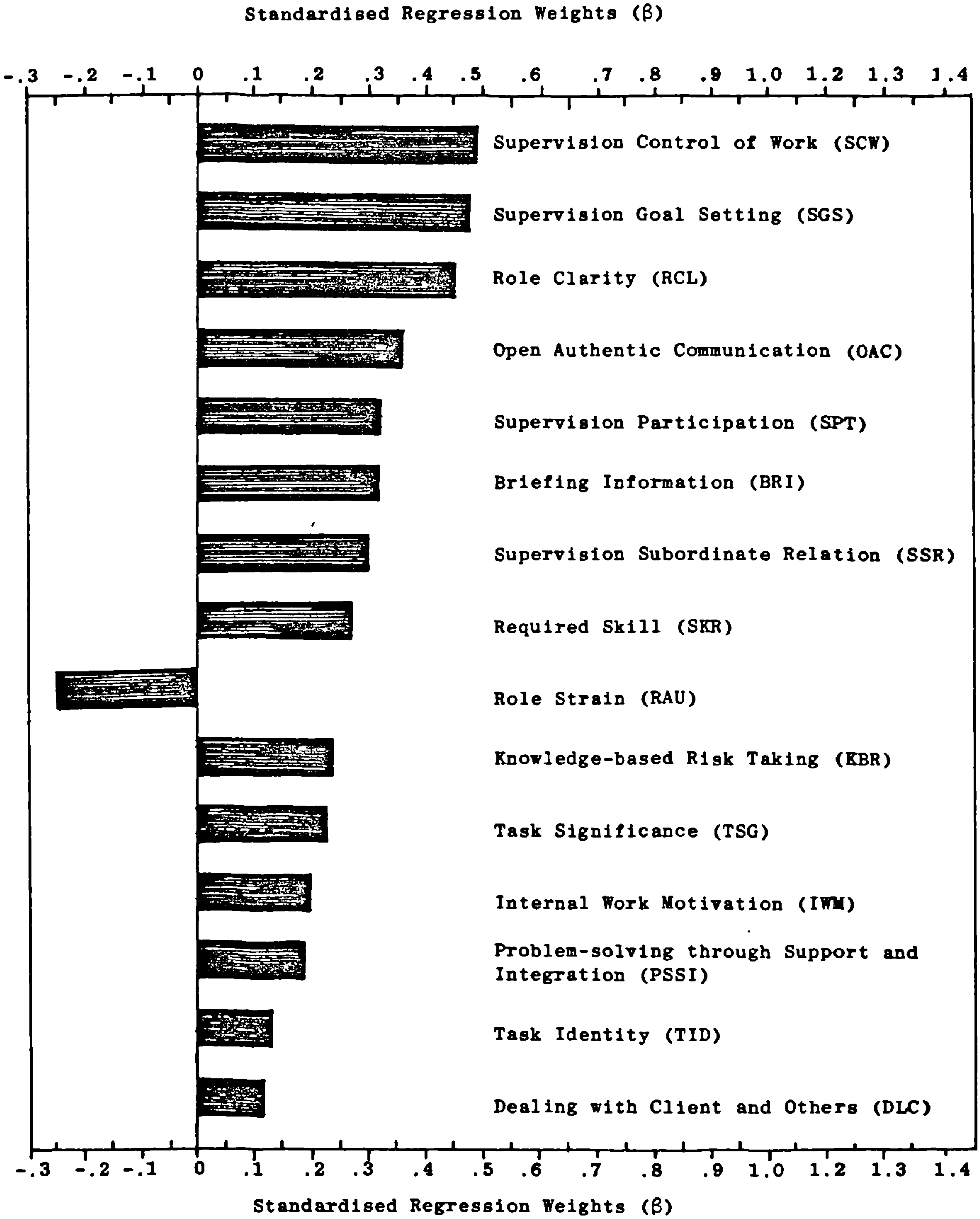


Figure 20: Standardised Regression Weights of the Independent Variables on the Dependent Variable (QA)

Authentic Communication and Knowledge-based Risk taking - have been found to exert significant positive influence on quality achievement on site. Hypothesis B2 has not support of data, and the non-significant negative influence is in contradiction to postulation. Support for hypothesis B3 is apparent and the positive impact by the Internal Work Motivation variable on quality achievement is in accord with postulation. With regards to main hypothesis B4, Subordinate Relations variable as one of the dimensions of Work-Place-Supervision paradigm does not contribute significantly in the regression toward the achievement of quality on site. The remaining four variables of the Work-Place-Supervision paradigm - Control of Work, Goal Setting, Problem Solving and Participation, have significant positive impact on the achievement of quality on site. This is in accord with postulation. Hypothesis B5 in which the achievement of quality on site has been advanced to be positively influenced by Supervision Satisfaction has no support of data. Furthermore, the negative sign of influence of the Supervision Satisfaction variable on quality achievement is in contradiction to what has been proposed. With regards to hypothesis B6, Role Strain variable has a significant negative impact on the achievement of quality of work on site associated with the duties of the Clerk of Works on site. The direction of influence of the Role Strain variable is in accord with postulation. Hypothesis B7 has the support of data. The Role Clarity variable has significant contribution to the regression. The positive influence of the aforesaid variable on the achievement of quality on site is in accordance with postulation. It could be deduced that there is a greater chance for the Clerk of Works to contribute significantly toward the achievement of quality on site if his role is clearly defined and communicated to the people concerned on the course of his duties on site. This is in accordance with theoretical rationale and experiential expectation.

For additional information on the completed hypothesis testing, we now consider the coefficient of multiple determination (R^2). The summary of R^2 coefficients are tabulated in Table 32. It is evident from the table that the design core job dimension variables - Required Skill, Task Identity, Task Significance, Job Autonomy, Feedback from the Job, Dealing with Client and Others and Briefing Information have made relatively small contributions to the variance in QA. The proportion of variance explained stands at 22.3%. The low value of R^2 might be attributed to the moderate sample size in the research. Slightly higher contribution to the variance in QA has been made by Site Team Collaborative Interpersonal Relationship variables. Specifically the variables - Problem Solving through Support and Integration, Open Authentic Communication, Knowledge-based Risk Taking in combination with Supervisor Initiating structure and Internal Work Motivation accounted for 36.2% of the variance in QA.

Table 32 Presentation of Coefficients of Determination (R^2)

Independent Variable	Dependent Variable	Coefficient of Determination (R^2)
SKR TID TSG AUT FBC DLC BRI	QA	0.22
PSSI OAC KBR INS IWM	QA	0.36
SCW SGS SPS SSR SPT SAT	QA	0.35
RAU RCL	QA	0.20

Similarly 35% of the variance in QA was accounted for by Work-Place-Supervision variables where the variables involved are: Control of Work, Goal Setting, Problem Solving, Subordinate Relations and Participation plus Supervision Satisfaction. The final contribution to the variance in QA have been made by Role Dimension variables. Role Strain and Role Clarity accounted for just 20.3% of the variance in QA. The low value of R^2 in this regard might also be attributed to the sample size in the research. The small R^2 values from the results of the research also indicate that only a small proportion of the total variability in the QA can be accounted for by the aforementioned independent variables used in the equations. This suggests that numerous other unmeasured or random factors also influence the size of the QA variable.

Attention is now turned to the remaining hypotheses that have not been supported by data. Hypotheses B2, B5 and parts of hypotheses A1 and B4 lack support of data. As indicated earlier the computed sign of the standardised regression coefficient has to be in the direction of postulation, and its magnitude has to be significantly different from zero, before a particular hypothesis is supported. If a hypothesis has not been supported by data due to its failure to reach statistical significance, then the following possibilities could be proposed: the sample size should be greatly enlarged in order to confirm or disprove what has been found; or the theory behind the proposition needs to be reappraised; or there is need to improve the psychrometric properties of the measuring instrument.

CHAPTER 12

DISCUSSION AND CONCLUSION

12.0 DISCUSSION AND CONCLUSION

This section of the thesis is concerned with a number of issues regarding the outcome of the research and the implicative aspects in the management of quality in construction for building designers and site management. Certain implications can be deduced for the understanding and enhancement of perceived quality achievement in building construction. To facilitate the discussion, a prior analysis of the relative importance of the independent variables and their impacts on the dependent variable will be undertaken. Such an analysis will heighten our appreciation of the relative importance of the independent variables in terms of the impact on the dependent variable. This acquired consciousness is a further step forward in our understanding of the phenomenon surrounding the procedures for perceived achievement of quality in building construction.

It is recognised that attainment of quality in construction is to a large extent dependent upon our capacity to gain a mastery of events to ensure an intended outcome. As such the discerning of variables with the magnitude of their individual impacts delineated will provide possible avenues for building designers and site management to pay particular attention to in the management of quality in construction.

Since the primary interest is the assessment of the impact of the independent variables on the criteria variable, Lewis-Beck [188] has noted that an obvious procedure is to compare the magnitudes of the standardised partial slopes or regression weights as shown in Figure 21 so computed through the regression analysis. The standardised partial slope estimate, or beta weight as often called, indicates the average standard deviation change in the dependent variable with a standard deviation change in an independent variable, when the other independent variables are taken into account.

12.1 BUILDING DESIGN SETTING

An examination of Table 31 reveals the magnitude of each of the independent variables associated with particular hypotheses. The briefing information variable (BRI) has been discerned to be the first in relative importance among the variables in the building design paradigm. Its impact on the perceived quality achievement variable measured by the total effect is computed at 0.32. This is followed by the required skill (SKR) variable with a total effect of 0.27. The next in order of importance is the task significance (TSG) variable with a total effect of 0.23. The remaining variables are task identity (TID) and dealing with client and others (DLC) variables having a total effect of 0.13 and 0.12 on perceived quality achievement variable respectively. Though, the individual impact of these variables are relatively modest, however, they do represent an insight in the management of building project at the design stage and provide an opportunity for building designers to potentially influence the achievement of perceived quality on site.

It is regrettable that in most construction project situations, work on site commences without the design of the building project being completed and finalised, where the detail working drawings and other project requirements are not fully reappraised, even before going to tender. A great deal of time and effort is spent in getting the work started on site, as soon as possible without fully addressing 'the design process'. In fact it is not uncommon in many construction sites to have unclear/missing project information on drawings and bills of quantities; and to have low quality design when the design detail, or material specification, was well below the standard of the rest of the building. Other familiar occurrences are where there is no co-ordination of design, for example, differences between architects' and engineers' drawings were causing confusion on site.

Addressing the 'process' in a design situation that result in the 'product' of design could be the way forward to eliminate a number of problems encountered. Where the 'requirements' are clearly identified and defined and their 'method of conformance' agreed and linked through every phase of the process. And the 'tasks' are identified in each phase in such a way that the common elements of the process in each task can be related in order to ensure that conformance is achieved.

If the goal is to achieve perceived quality in the completed building in a given project, then addressing the design 'process' before the design 'product' - where the required skill associated to a given task, the design task fully identified and signified, the extent of dealing with client and other members of the design team (e.g. structural/services engineer(s), quantity surveyors, etc.), clearly identified and defined, and the briefing information fully reviewed and co-ordinated - is the way forward.

The sensitivity of the briefing information variable to manipulation at the design stage is borne out of the fact that for every standard unit incremental change in the briefing information, brings a positive return of 0.32 standard unit in perceived quality achievement. The briefing information is likely to enhance the right choice of products and product identification at the early stage of the project and that required information is likely to be detailed in the drawings before the drawings and the accompanying contract documents are used on site.

Paying attention to these areas in specifying items for construction is important; in that, in 1983 BRE [124] published an alarming report on the non-compliance of building products. It is often likely that far too many specifiers in the building industry take the claimed compliance of a product to British Standard on trust, without further assurance.

The next variable pliable to manipulative action during the design phase is the required skill or the skill variety needed to accomplish a given task. In view that one standard unit increase in required skill brings a positive return of 0.27 standard unit in the achievement of perceived quality. This points to the notion that, the appropriate building designer with the prerequisite experience should undertake the given project; for instance, the designer who specialises on housing projects with longstanding experience is more appropriate for a given housing project. According to theoretical expectations, experience acquired through the practice of design is seen as readily available and quicker to use. The skill of the building designer through the acquired experience will likely enable the designer to predict what problems might arise during design and how to know in advance what information sources might be appropriate. Furthermore, experience and general knowledge of building construction gained from both education and practice will likely enable design decision to be made in terms of what might normally be an appropriate answer to the requirements of brief and site.

The task significance variable is the next pliable to manipulation during the design stage. For one standard unit increase in task significance corresponds with a positive return of 0.23 standard unit in the achievement of perceived quality. Designers' time is often fragmented between a variety of tasks, particularly in small offices and designers dealt with more projects each day. The need for the designer to thoroughly consider the importance and intricacies of a given design task is apparent and vital for the successful completion of the job at hand.

The remaining variables in the design paradigm subject to manipulative action during the design process are task identity and dealing with client and others. One standard unit increase in task identity brings a positive return of 0.13 standard unit in the achievement of perceived quality. Similarly, for one standard unit increase in dealing with client and others corresponds with a positive return of 0.12 standard unit in the achievement of perceived quality.

One of the main objectives in task identification relating to any given design job is to identify any special or unusual contingencies/requirements. This entails the building designer to conduct during the earliest practical phase of design and specification development, a sufficiently extensive review of target specification and other project requirements to ensure;

1. the timely identification and acquisition of any controls, processes, information sources, design tools and skills of related personnel that may be needed to ensure successful design;
2. identification of design interfaces;
3. tolerances to avoid irrational limits; and
4. statutory requirements.

The importance of task analysis in the design phase has been stressed in the literature. Cornick et al [89] for instance have proposed quality management model for building project though, the model seemingly lacks conceptual and theoretical considerations. The proposed model consists of combination of a standard process model applied to a task analysis of the specific activities involved in the design process. They have identified separate tasks which must be understood if a chain of conformance to requirements is to be achieved through eliminating the deficiencies in the elements of the process.

Direct dealing with the client and other members of the design team is an important aspect in the design process. Research [197] has indicated the value of close working relationships with the client. The client-designer relationship is seen here to have an important influence on the smooth and steady progress of the design - the designer obviously benefitting from clear instructions even if these were only to give him an absolutely free hand.

12.2 SITE CONSTRUCTION PROCESS

The achievement of perceived quality at site level poses many issues, as many individuals are involved and their individual contributions are quite essential for the successful completion of the project. We shall now discuss the outcome of the research regarding on-site management and construction process.

It will be noted from Table 31 that the site-collaborative inter-personal relationship variables: problem solving through support and integration; open authentic communication; and knowledge-based risk taking; all have reached the level of significance for their contribution to perceived quality achievement. The achievement of perceived quality on site is a team effort. In view that one standard unit increase in problem solving through support and integration brings a positive return of 0.19 standard unit in achievement of perceived quality.

Likewise, one standard unit increase in open authentic communication corresponds with 0.36 standard unit in achievement of perceived quality. And one standard unit increase in knowledge-based risk taking brings a positive return of 0.24 standard unit in perceived quality achievement. Perceived quality on site is seen here to be achieved through effective close teamwork. The team must be organised, structured correctly and allowing unrestricted communication and a shared general understanding of the project and its objectives. The nature of the site should be characterised in such a way that commitment to the job by everyone concerned is encouraged by site management. Everyone should become involved to some degree in dealing with and helping to sort out problems, not necessarily strictly to do with their own work, but involving themselves with the job as a whole. To the extent that if one does not contribute to the solution of a problem, then one is part of that problem. That is, site management should create conducive site environment, where a consultative approach to problem solving - anyone on site could raise questions and many individuals could contribute to solutions - become possible. A deliberate policy by site management with involvement of top management at the head office, to create conducive environment for close teamwork through manipulation of site collaborative interpersonal relationship variables is the way forward.

The next variable subject to manipulation by site management is the internal work motivation variable. For one standard unit increase in internal work motivation brings a positive return of 0.20 standard unit in achievement of perceived quality. Obviously extra effort and attention by site management on internal work motivation would benefit perceived quality achievement. Developing healthy worker attitudes whereby workers look to the job and the contractor as a source of satisfaction; administering praise and build respect; assigning responsibility for a major task to a crew with understanding that they are held responsible; sufficient and unambiguous information about the work to be done, and good honest leadership could provide the way forward to motivate workers. Deliberately arrived at and clearly understood lines of authority by site management could go a long way to motivate workers. The active control, organisation and co-ordination of sub-contractors, so that work between different trades is carried out smoothly without delay and interruption could assist in motivating workers.

In most construction sites a subordinate's immediate supervisor is singularly important in determining the subordinate's work environment, and under some circumstances can have significant impact upon work performance. From the result of the research, it could be noted in Table 31 that four variables of the supervision module of the research instruments have reached significance level. These variables: control of work; goal setting; subordinate relations and participation are pliable to manipulative action by site management. In view that one standard unit increase in control of work brings a positive return of 0.49 standard unit in perceived quality achievement, and one standard unit increase in goal setting increases the chance of perceived quality achievement by 0.48 standard unit. Likewise, one standard unit increase in subordinate relations corresponds with 0.30 standard unit in perceived quality achievement, and one standard unit increase in participation by site operatives on matters and decision pertaining to their work increases the chance of perceived quality achievement by 0.32 standard unit. As noted earlier in this thesis, the three common elements in supervisory roles include: concern for the processes and tasks to be supervised; concern for the people involved in these processes and tasks and concern for the co-ordination and control of these processes for the given project requirements and its objectives. The aforesaid point to the intensification by site management in such areas as breaking work down to manageable tasks; sequencing the work in a rational way; estimating the work content of a task; comparing the work content with the resources needed and available; checking against target completion dates; resource smoothing: avoiding under- and over-loading; checking and recording the time spent on a task; and taking corrective action when necessary. It would also be of benefit to perceived quality achievement if site management pays particular attention to work facilitation in 'goal setting' whereby supervisors help subordinates to have clear and integrated goals so that they can know what they should be doing. This should be established at the time of initial arrival of workmen on site to accomplish a definable segment of work and at any time new workmen or crew arrive for assignment to work. The contractor's quality control system must foster the transfer of information on quality requirements in the contract to workers before starting any work, obtain demonstration from workers that the specified quality of work can be produced and motivate workers to continue to produce the required quality of work. Prevention of problems, rather than sorting out defects has been recognised as a cost effective means of ensuring quality and improving productivity. 'Getting it right first time' must therefore be relevant to construction.

By tapping labourers' brains, that is, seeking workers' advice on how to achieve the required quality, management can make labour an active 'participant' in managing the work place and thus increase the chances of meeting or conforming to project requirements. Site management can readily apply the quality control concepts beyond the manufacturing industry province where they originated, so that they are used on a company-wide basis. The quality control circle or work group which placed problem identification and problem solving techniques in the hands of operatives could be a significant development for involving a broader base of people. According to theoretical expectations a worker would like a job where he earns a good living. Even though he is paid well to do the job, in addition, the work ought to give him a sense of participation in the creative process. Therefore, joint participation during the supervision process, to decide on matters pertaining to work at hand by both the workers and the supervisory staff is an essential ingredient in any effort to improve the effectiveness of site organisation and to provide employees with a measure of involvement adding dignity and worth to their work life.

12.3 ROLE OF CLERK OF WORKS

Within the site management cohort, comes the client's representative - the Clerk of Works - who is usually appointed by the client or the project architect on behalf of the client. It is recognised that the Clerk of Works is an invaluable member of the building team whose contribution is vital to the successful completion of the project definable as to quality. Examination of Table 31 reveals the magnitude of the role dimension variables, where the role strain and role clarity associated with the duties of the Clerk of Works have reached level of significance in their impact on perceived quality achievement. These variables could be subject to manipulation in the management of perceived quality in building construction. It will be of benefit to perceived quality achievement, right at the beginning of the project, to clearly define the role of the Clerk of Works and give him the necessary responsibility with adequate authority and to communicate these to the people concerned on site. From the standpoint, that one standard unit increment in role strain corresponds with 0.25 standard unit decrease in Clerk of Work's contribution to perceived quality achievement. On the other hand, one standard unit increase in role clarity brings a positive return of 0.45 standard unit increase in the contribution by the Clerk of Works toward the achievement of perceived project quality. Role clarity and responsibility with adequate authority represent a profitable domain for perceived quality achievement in building construction associated with the duties of the Clerk of Works. The clearly prescribed responsibility and authority will allow the Clerk of Works to evaluate quality problems and to initiate, recommend or provide solutions. This however, should not be construed as meaning that only the Clerk of Works is really concerned with perceived quality matters. Rather, his contribution as a member of the building team is clearly spelled out, for he is being appointed and paid to represent the interest of the client toward successful completion of the project definable as to quality. As not earlier, achievement of perceived quality on site is a team effort and the Clerk of Works is an invaluable member of that team. Research [21] has indicated that for a disturbing number of problems on site, particularly the serious ones, identification of the problem did not result in effective remedial action being taken. Major reasons for this were that the Clerk of Works did not normally have the authority to press for effective remedial action and architects put too little effort into understanding and solving problems on site.

12.4 CONCLUDING REMARKS

In conclusion, the implementation of a conscious policy decision by building designers and site management to manipulate the highlighted variables in a concerted effort would go a long way toward the enhancement of perceived quality in the management of building projects. The magnitude of the impact of each of the independent variables on the dependent variable (QA) is summarised in Figure 21 for ease of reference. With its emphasis on meeting requirements, perceived quality achievement in the design phase must address the 'process' that result in the design 'product' to ensure that requirements are clearly defined and their method of conformance agreed and linked through every phase of the process. At site level, management should not only be concerned with tasks to be performed, but also pay good attention to the processes and the people performing the tasks. In such a way that environment is created with workers and other site staff attempting to solve the problems at their level of competence and experience, thus allowing supervisory staff and the site agent/manager an opportunity to face other management and organisational issues particularly those dealing with outside the site environment. As this happens we will find ourselves well on the road to re-establishing the type of site quality leadership of which we are capable.

12.5 SUGGESTIONS FOR FURTHER RESEARCH

A typical building project involves bringing together a new group of designers, engineers and contractors to produce a one-off product. The absence of continuity of relationship between design and construction poses problems unique to the construction industry which have consequences upon the achievement of perceived quality in a given project. In addition, a new team of sub-contractors and operatives will generally be assembled for each project. The industry has no long established tradition of management system which increases confidence that the completed building will conform to specified requirements.

As a result of this research a number of areas appear to suggest further investigation.

1. It is recommended that further studies should be conducted that involve the testing of those presently unsupported hypotheses with greater sample size,

either in their intact or modified forms, alongside with others using the multiple regression analytical technique or path analytical method, in order to shed more light on these unsupported hypotheses.

2. As mentioned earlier, the achievement of perceived quality in building construction involves a wide range of factors and activities, the incorporation of new variables, for instance, the extent of client's participation at the briefing stage and the extent of site operatives' involvement in decision taking pertaining to their given tasks during the supervision process may bring further understanding and enhancement for the achievement of perceived quality in building construction.

   Specifically, this may effect an improvement in compatibility with data, and the explanatory power of the multivariate model may be enhanced. A retrospective view of the relatively low values for the coefficients of determination as tabulated in previous Table 32 goes further to reinforce the scope for the inclusion of more variables.

3. Further research in this direction with a greater sample size and greater number of ongoing construction projects may possibly improve the empirical properties of the research instruments. Though many of the

scales used in this research were utilised in a variety of research settings in the past and have established statistical reliability and validity, further research effort in this direction using these instruments will provide more confidence and make the instruments 'final' relatively speaking. And attenuation of measurement errors will be brought about by better psychrometric properties and hence a lesser chance of an induced aberration to the parameter estimates.

4. Studies could be conducted on on-going new construction projects to further diagnose the design core job characteristics to determine if (and how) they might be established theoretically as objective design core job dimensions.

5. The study should be repeated on other kinds of new building construction projects, for instance, hospital buildings, educational buildings or commercial projects using similar methodology and the results be compared with those from this study towards our greater understanding and enhancement of perceived quality achievement in building construction.

6. To develop and improve the existing management procedures with well defined roles for the major participants to overcome the many areas of ill-defined responsibilities which lead to poor quality control decisions on site.

In conclusion, there is opportunity for enlargement and elaboration in the present research scheme. Research of this kind and its methodological stance is an ongoing process along an evaluationary route towards an ultimate goal of generating a better and more complete analytical insight into the phenomenon under investigation. Our continuing understanding of the construction management phenomena is to a large extent dependent upon our persistence in attempting to unravel the rather daunting complexity and perplexity enveloping the research issues. The above mentioned recommendations shall constitute guidelines which further research effort may find beneficial.

12.6 LIMITATIONS

The aim of this section of the thesis is to shed some light on the limitations of the research.

The phenomenon surrounding the achievement of quality in building construction involves the operational techniques and activities that are used to fulfill requirements for quality where all the planned and systematic actions necessary to provide adequate confidence that the completed building will satisfy given requirements is a daunting task. In other words, the success of any undertaking such as design and construction of a building project, directed to the fulfilment of a need, depends on the collective and individual success of its several activities and functions, of which some are concerned with attainment of the quality of the product and hence directly affect success; while the remainder are concerned with enabling and ensuring that the direct activities can be, are being and have been effective and hence have an indirect effect on success covers the entire building process.

This is quite beyond the grasp of this thesis and points to the limitations of this research for it is not possible to take every activity into measurement operation nor to cover the areas in the literature.

The data which have been collected throughout this study both at pretest level and main data collection stage is considered to be from a small sample size. The research sample is therefore not random and may not be typical of the underlying population. The process of random sampling is practically unattainable in many research settings and particularly so in the present case. The reason for the small sample size in this research both at pretest level and main data collection stage might be attributed to the time spent at the beginning of this research to design the first set of the questionnaire given in Appendix 2 which was later discovered to be inappropriate for the main data collection and subsequent analyses. This imposed limitations on the time and the resources available on the selection of the final research instruments given in Appendix 1 and the main analyses and writing up of the thesis.

The findings and the results of this study regarding the achievement of perceived quality in building construction were built entirely on the views and assessment of the respondents engaged on the construction projects. The sample size was considered small, as mentioned earlier. The aforesaid is categorically insufficient to facilitate random sampling an ideal situation that this research cannot possibly achieve. Hence a cautionary note on generality of the research results may be in order.

However, this research has postulated a number of hypotheses and used proven methodology to test these hypotheses. Conclusions were reached within the above limitations and contribution was therefore made toward understanding the achievement of perceived quality in building projects, as one of the diverse areas of construction management.

12.7 ACHIEVEMENTS

The move toward contractors and now even building designers operating quality systems is gathering momentum particularly from specifying agencies with government backing. The development of QA schemes and their accreditation is potentially seen as a multimillion pound industry and there is considerable impetus and much competition in the development of schemes. The success of any undertaking such as design and construction of building project toward achievement of quality and other project objectives is pivotal upon the successful management of the project's design and its site construction. An understanding of the agents or forces surrounding the achievement of quality is imperative and hence a pre-requisite for success. The attempt made in this thesis to present a conceptual framework for perceived quality achievement in building construction as integration of the project:- addressing the design process and site organisation-and-management should be seen as a development toward our awareness and reappraisal of our management practices in the design and site construction phases. This conceptual framework is a synthesis allowing the understanding and awareness of perplexing issues surrounding the achievement of perceived quality in building construction. It permits us to critically examine and treat the quality achievement phenomenon and thus offers an opportunity for founding our insight on theoretical basis.

The conceptual framework affords a guiding criterion for the eventual establishment of a theory of quality achievement in building construction, an area of growing importance in construction management.

The application of quantitative analytical techniques through multiple regression analysis has facilitated the quantification of regression weights and the impacts of the independent variables on the criteria variable. The relative importance and influences of the independent variables offer a potentially useful application by practitioners in the management of quality in building projects. Those variables isolated on the basis of their relative importance and impacts on perceived quality achievement should form the focus of attention and policy decision in the management of quality in building projects.

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A P P E N D I C E S

Table A Relationship of BS 5750 to the Process of Site Management and also to Problem Areas in Site Management

BS 5750 Clauses	Comment
4.1 QUALITY SYSTEM. The supplier shall establish, document and maintain an effective and economical quality system to ensure and demonstrate that material or product conform to the specified requirements. The documented quality system shall include quality management objectives, policies, organisation and procedures to demonstrate compliance with the requirements of this standard.	4.1 Management in the construction industry has been reluctant to take the lead in the attainment of quality it being traditional to completely leave this to able personnel without any positive direction. The establishing of a quality system endorsed by senior management would provide a vehicle for their involvement.
4.2 ORGANISATION 4.2.1 PERSONNEL RESPONSIBLE FOR FUNCTIONS AFFECTING QUALITY. The supplier shall delegate, to all personnel responsible for functions affecting quality, both the defined responsibility and the authority to identify and evaluate quality problems and to initiate, recommend and provide effective solutions.	4.2.1 Quality Control research has demonstrated that the positive allocation of roles and responsibilities is of paramount importance on site and is usually not done. The foreseeable should be formally allocated in advance and the unforeseeable should be able to be assigned in an ad-hoc manner very quickly and the management organisation should allow for this.
4.2.2 MANAGEMENT REPRESENTATIVE. The supplier shall appoint a management representative, preferably independent of other functions, who shall have the necessary authority and the responsibility for ensuring that the requirements of this standard are implemented and maintained.	4.2.2 Too much emphasis on the independence fro production of the contractors quality staff coul act against the creation and maintenance of the good working relationships necessary for good quality work on building sites.
4.2.3 PURCHASER'S REPRESENTATIVE. The purchaser may appoint a representative, hereinafter referred to as the 'Purchaser's Representative', to obtain assurance on his behalf that the system established in compliance with this standard is effective. The supplier shall provide reasonable access for this purpose.	4.2.3 Too little emphasis has been placed on th need for independence from production and design of the clients quality manager or 'representativ as he is called in the British Property Federation (BPF) system of contracting. This system of contracting was itself born out of dissatisfaction with performance under tradition methods such as those involving the architect and his Clerk of Works.
4.3 REVIEW OF THE QUALITY SYSTEM. The quality system established in accordance with the requirements of this standard shall be periodically and systematically reviewed by the supplier to ensure its continued effectiveness. Records of the review shall be maintained and be available to the Purchaser's Representative.	4.3 The building site as the production centre of the industry is transitory therefore it is important that the Quality Systems can be made contract related and tuned to suit each site.
4.4 PLANNING. The supplier shall establish a procedure for conducting a sufficiently extensive and timely review of the specified requirements to ensure:	
(a) the adequate and documented control of design, development, manufacturing and installation activities;	4.4 (a) Production drawings and specifications-
(b) the identification and documentation and acquisition of any controls, process, inspection equipment, fixtures, tooling, manpower resources and skills that may be needed to achieve the required quality;	
(c) as necessary, the updating of quality control, inspection and testing techniques including the develoment of new instrumentation;	
(d) the identification of any measurement involving measurement capability that exceeds the known state of the art or any new measurement capability needed to inspect the product, in adequate time for such capability to be developed;	
(e) the clarification of standards of acceptability for all features and requirements including those which contain a subjective element;	4.4 (e) Samples, prototypes, mock-ups, specifications;
(f) the compatibility of the design, the manufacturing process, installation, inspection procedures and the applicable documentation before production begins;	4.4 (f) Co-ordination;
(g) the preparation of documented quality plans when included in the specified requirements.	

BS 5750 Clauses	Comment
4.5 WORK INSTRUCTIONS. The supplier shall develop and maintain clear and complete documented instructions that prescribe the communication of the specified requirements and the performance of work in design, development, manufacture and installation, which would adversely be affected by lack of such instructions.	4.5 Work instructions to sub-contractors and suppliers are provided by the main contractor - usually as extracts of the project information but sometimes generated by the main contractors own design teams.
4.6 RECORDS. The supplier shall develop and maintain records that demonstrate achievement of the required quality and the effective operation of the quality system. These records shall be retained and made available for evaluation by the Purchaser's representatives for an agreed period. Pertinent sub-contractor records shall be an element of this data. Records shall include, as appropriate, explicit identification of the material, part, sub-assembly, assembly, equipment, sub-system or system, the nature and number of observations made, the number and type of deficiencies found, the quantities approved or rejected and the nature of rectification and corrective action taken.	4.6 Records are most important where traceability is very important, e.g. the Nuclear Industry. However, on a building site, the working environment is the most important factor in the achievement of quality and QA must be implemented without unnecessary bureaucracyin order not to alienate.
4.7 CORRECTIVE ACTION. The supplier shall establish and maintain documented procedures to provide for:	
(a) a continuing analysis of concessions granted and of material scrapped, modified or otherwise repaired to determine the cause and the corrective action needed;	4.7 (a) There is a problem in the UK building industry. In America they try to get it right first time and concessions come expensive.
(b) a continuing monitoring of processes and work operations and analysis of records to detect and eliminate potential causes of non-conforming material;	4.7 (b) This suggests a higher level of inspection than is common currently. Quality cannot be inspected rigorously, however it is reasonable to expect to be able to draw constructive feedback from inspection.
(c) the initiation of appropriate action upon receipt of non-conforming supplies;	4.7 (c) There is a strong tradition on well organised sites that non-conforming supplies are never allowed to be unloaded.
(d) an assurance that corrective actions are effective.	4.7 (d) Agreement must be reached on any correctiv action of either work or materials, e.g. re-classification of materials for less demanding situations (chipped or otherwise unacceptable facing bricks for plastered walls, etc).
4.8 DESIGN CONTROL. The supplier shall establish and maintain control of design functions wherever performed. Such functions shall include: (a) the provision where necessary of a design and development programme; (b) the provision of a code of design practice and procedure; (c) the investigation of new techniques; (d) the identification and control of design interfaces; (e) the preparation and maintenance of drawings, specifications, procedures and instructions; (f) the control of physical and functional tolerances to avoid the use of irrational limits; (g) the consolidation of statutory requirements, including those for health and safety; (h) the evaluation of new material under appropriate environmental conditions; (i) the control of the reliability and value engineering tasks; (j) the establishment of design review procedures to ensure progress towards the achievement of the design and development programme objectives through the timely identification of problem areas; (k) the use of defect data feedback from previous designs, where appropriate.	4.8 This can be considered in two ways:- (1) That the contractor has no design control over the building and that, therefore, this section should be wholly ascribed to the design professionals. (n.b. excluding design and build). (2) That this section applies to temporary work where the contractor is responsible for desic e.g. false work. In this case b, c, f, g, and k are all relevant.

BS 5750 Clauses	Comment
As a result of the requirements given in (a) to (k), the engineering data developed for purchasing, manufacturing, inspection, installation purposes, etc. shall reflect the specified requirements.	
4.9 DOCUMENTATION AND CHANGE CONTROL. The supplier shall establish and maintain control of all documentation that relates to the requirements of this standard. To this end the supplier shall ensure that:	
(a) the pertinent issues of appropriate documents are available at all locations where operations essential to the effective functioning of the quality system are performed;	4.9 (a) There is a problem of site handling and storage of project information. There is also the problem of getting information quickly to the site since it usually goes first to the contractors head office.
(b) all changes to documentation are in writing and are processed in a manner that will prompt action at the specified and effective point;	4.9 (b) Architects instructions, work instruction or similar are usually forwarded to areas, sub-contractors or suppliers from head office via the site office and this is often not well organised.
(c) records are maintained of changes as they are made;	
(d) documents are reissued after a practical number of changes have been issued;	
(e) provision is made for the prompt removal of obsolete documents from all points of issue or use.	4.9 (e) There is a problem with superseded drawings. Contractors do need to keep them as a record for subsequent claims for variations.
4.10 CONTROL OF INSPECTION, MEASURING AND TEST EQUIPMENT. The supplier shall provide, control, calibrate and maintain inspection, measuring and test equipment suitable to demonstrate the conformance of material to the specified requirements. Equipment shall be used in a manner which ensures that measurement uncertainty is known and is consistent with the required measurement capability. The measurement and calibration system for this equipment shall be in accordance with the requirements of BS 5781.	4.10 Can be readily interpreted in terms of site engineering equipment - optical, laser; tapes, rods, gauges, etc.
Where jigs, fixtures, templates, patterns or other such devices are used as suitable forms of inspection, they shall be proven to be capable of verifying the acceptability of material prior to release for use during manufacture, and shall be re-proven at established periods. The supplier shall establish the extent and frequency of such proving and shall maintain records as evidence of control. Design data pertaining to tools and gauges shall be made available, when required by the Purchaser's Representative, for verification that the devices are functionally adequate.	
4.11 CONTROL OF PURCHASED MATERIAL AND SERVICES	4.11
4.11.1 PURCHASING. The supplier shall be responsible for ensuring that all purchased material and services conform to specified requirements.	4.11.1 This is the basis of QA for construction - being virtually totally dependent upon sub-contracting the industry has become accustomed to using the careful choice of sub-contractors as its main agent to achieving success.
The selection of sources and the type and extent of control exercised by the supplier shall be dependent upon the type of material and the sub-contractor's demonstrated capability.	
The supplier shall ensure that controls are effective, including, if necessary, by monitoring at the sub-contractor's plant.	
4.11.2 PURCHASING DATA. Each purchasing document shall contain a clear description of material and services ordered, including, as applicable:	4.11.2 The importance of accurately describing materials or work when placing orders (contracts) is now well understood. All of the problems have not been overcome and methods (technical and contractual) are currently being investigated.
(a) the type, class, style, grade or other precise identification;	
(b) the title or other positive identification and applicable issue of specifications, drawings, process requirements, inspection instructions and other relevant technical data.	

4.11.3 RECEIVING INSPECTION. The supplier shall ensure that no incoming material is used or processed until it has been inspected or otherwise verified as conforming to specified requirements. NOTE. Material may be released for urgent production purposes, providing it is identified in a positive manner that will permit immediate recall and replacement in the event of non-conformance. In determining the amount and nature of receiving inspection, consideration shall be given to the control exercised at source and documented evidence of quality conformance provided.	4.11.3 There is a strong tradition on well organised sites that non-conforming supplies are never allowed to be unloaded.
4.11.4 VERIFICATION OF PURCHASED MATERIAL. The Purchaser's Representative shall be afforded the right to verify at source or after receipt that purchased material conforms to specified requirements. Verification by the Purchaser's Representative shall not relieve the supplier of the responsibility to provide acceptable material nor shall it preclude subsequent rejection. When the Purchaser's Representative elects to perform verification at the sub-contractor's plant, such verification shall not be used by the supplier as evidence of effective control of quality by the sub-contractors.	4.11.4 Clerk of Works or other client appointed inspector. See 4.2.3.
4.12 MANUFACTURING CONTROL	4.12
4.12.1 GENERAL. The supplier shall ensure that manufacturing operations are carried out under controlled conditions. Controlled conditions shall include documented work instructions defining the manner of manufacturing or processing, suitable manufacturing equipment and any special working environment. Criteria for workmanship shall be prescribed to the greatest practical extent by written standards, photographs or representative samples. Where appropriate, the criteria for workmanship shall be agreed by the supplier and the Purchaser's Representative. The supplier shall provide for inspection, as required, after each work operation that affects quality. Alternatively, control by monitoring process methods, equipment and personnel shall be provided. When essential, both inspection and monitoring shall be provided. Inspection methods or controls shall be corrected whenever their unsuitability is demonstrated. 4.12.2 CONTROL OF SPECIAL PROCESSES. The supplier shall establish and maintain control of all special processes that form part of production or inspection. Equipment, essential processing environment and any necessary personnel qualifications shall be prescribed to the satisfaction of the Purchaser's Representative.	4.12.1 The working environment is not easily controlled and this creates problems where processes require particular conditions. There are the standard problems such as bricklaying or plastering in freezing weather and newer problems such as the use of adhesives for structural glazing in cold wet weather. To be covered in new BS for workmanship? However, specifications are really an issue of design. Lack of objective standards opens the way for a great deal of dispute in the building industry.
4.13 PURCHASER SUPPLIED MATERIAL. The supplier shall establish and maintain procedures for the inspection, storage and maintenance of purchaser supplied material provided for incorporation into the supplies. Any such material that is lost, damaged or is otherwise unsuitable for use shall be recorded and reported to the purchaser.	4.13 This relates to the clients "artists and tradesmen" (e.g. carpet layers) in construction contractual terms and client supply items, e.g. fitted furniture.

4.14 COMPLETED ITEM INSPECTION AND TEST. The supplier shall perform all inspections and tests on the finished product or service necessary to complete the evidence of full conformance to specified requirements. Procedures for final inspection and test shall ensure that inspections and tests that should have been conducted at earlier stages have, in fact, been performed and that the data are acceptable.	4.14 Handover inspection.
4.15 SAMPLING PROCEDURES. Sampling procedures used by the supplier shall be in accordance with the specified requirements or shall be subject to agreement by the Purchaser's Representative.	4.15 Sampling procedures are well established for some materials, e.g. concrete. There may be some scope for increasing this approach.
4.16 CONTROL OF NON-CONFORMING MATERIAL. The supplier shall establish and maintain procedures for controlling material that does not conform to the specified requirements. These procedures shall include provision for identification, segregation and disposition as appropriate. All non-conforming material shall be clearly identified to prevent unauthorised use, shipment or mxing with conforming material. Holding areas or procedures, mutually agreed between the supplier and the Purchaser's Representative, shall be provided. Repair, rework or concessions on non-conforming material and reinspection shall be in accordance with documented procedures and, when applicable, shall be acceptable to the Purchaser's Representative. Adequate records, clearly identifying the material, the nature and extent on non-conformance and the disposition, shall be maintained.	4.16 There is a strong tradition on well organise sites that non-conforming supplies are never allowed to be unloaded.
4.17 INDICATION OF INSPECTION STATUS. The supplier shall establish and maintain a system for identifying the inspection status of material during all stages of manufacture. The supplier shall ensure the ability to distinguish between inspected and uninspected material by using some suitable form of identification.	4.17 There is a strong tradition of inspection stages in the construction industry. They are largely undocumented at present and this is the area where most of the people who are currently "having a go" at QA make some considerable effort, e.g. check lists.
4.18 PROTECTION AND PRESERVATION OF PRODUCT QUALITY. The supplier shall establish and maintain a system to control packing, preservation and marking processes (including materials used) to the extent necessary to ensure conformance to specified requirements and to identify, preserve and aggregate all material from the time of receipt until the supplier's responsibility ceases.	4.18 Again there is a strong tradition of sealing off and/or locking up completed areas of work both prior to and (especially) after final handover inspection.
4.18.1 MATERIAL HANDLING. The supplier shall provide methods of handling that prevent abuse, misuse, damage or deterioration.	4.18.1 Handling and storage of materials are two of the fundamental aspects of construction usually under the direct control of the main contractor. They are areas which have received much technical development (e.g. handling) and research (e.g. storage). They remain areas where vast improvements can be made.
4.18.2 STORAGE. The supplier shall provide secure storage areas or stock rooms for the isolation and protection of material, pending use or shipment. Appropriate systems for authorising receipt and the despatch to and from such areas shall be prescribed. To detect deterioration, the condition of materials in stock shall be periodically assessed.	
4.18.3 DELIVERY. The supplier shall arrange for the protection of the quality of the product after final inspection, including where appropriate, specified packing and preservation during transit. The supplier shall ensure, to the extent practicable, the safe arrival and ready identification of the product at its destination.	
4.19 TRAINING. The supplier shall establish a system for identifying training needs and certification requirements for all contracting, design, manufacturing, installation and quality assurance functions that would be adversely affected by lack of such training. All personnel performing such functions shall have the appropriate experience or training.	4.19 A topical subject. Continuing professional development (CPD), is becoming established althou not mandatory in design and construction management. There is a fear that skills at operative level are not being preserved and that the indust is being de-skilled. Most of the sub-industries have organisations who, given the right motivatio could administer training and certification schemes - some already do.

Table B QUANTILES OF THE KOLMOGOROV TEST STATISTIC[a]

One-Sided Test $p =$	.90	.95	.975	.99	.995	$p =$	.90	.95	.975	.99	.995
Two-Sided Test $p =$	.80	.90	.95	.98	.99	$p =$	.80	.90	.95	.98	.99
$n = 1$	.900	.950	.975	.990	.995	$n = 21$	.226	.259	.287	.321	.344
2	.684	.776	.842	.900	.929	22	.221	.253	.281	.314	.337
3	.565	.636	.708	.785	.829	23	.216	.247	.275	.307	.330
4	.493	.565	.624	.689	.734	24	.212	.242	.269	.301	.323
5	.447	.509	.563	.627	.669	25	.208	.238	.264	.295	.317
6	.410	.468	.519	.577	.617	26	.204	.233	.259	.290	.311
7	.381	.436	.483	.538	.576	27	.200	.229	.254	.284	.305
8	.358	.410	.454	.507	.542	28	.197	.225	.250	.279	.300
9	.339	.387	.430	.480	.513	29	.193	.221	.246	.275	.295
10	.323	.369	.409	.457	.489	30	.190	.218	.242	.270	.290
11	.308	.352	.391	.437	.468	31	.187	.214	.238	.266	.285
12	.296	.338	.375	.419	.449	32	.184	.211	.234	.262	.281
13	.285	.325	.361	.404	.432	33	.182	.208	.231	.258	.277
14	.275	.314	.349	.390	.418	34	.179	.205	.227	.254	.273
15	.266	.304	.338	.377	.404	35	.177	.202	.224	.251	.269
16	.258	.295	.327	.366	.392	36	.174	.199	.221	.247	.265
17	.250	.286	.318	.355	.381	37	.172	.196	.218	.244	.262
18	.244	.279	.309	.346	.371	38	.170	.194	.215	.241	.258
19	.237	.271	.301	.337	.361	39	.168	.191	.213	.238	.255
20	.232	.265	.294	.329	.352	40	.165	.189	.210	.235	.252
						Approximation for $n > 40$	$\frac{1.07}{\sqrt{n}}$	$\frac{1.22}{\sqrt{n}}$	$\frac{1.36}{\sqrt{n}}$	$\frac{1.52}{\sqrt{n}}$	$\frac{1.63}{\sqrt{n}}$

[a] The entries in this table are selected quantiles w_p of the Kolmogorov test statistics T_1, T_1^+, and T_1^- as defined by (6.1.1) for two-sided tests and by (6.1.2) and (6.1.3) for one-sided tests. Reject H_0 at the level α if T exceeds the $1 - \alpha$ quantile given in this table. These quantiles are exact for $n \leq 20$ in the two-tailed test. The other quantiles are approximations which are equal to the exact quantiles in most cases.

Source: CONOVER, W.J. - 'Practical Non-parametric Statistics' (83)

Table C Critical values for the outlier test

The values in the table in row n and column p' are $t(\alpha/n;\ n-p')$ for the choices of $\alpha = 0.01$ and 0.05. The layout of the table was suggested by Christopher Bingham. The table was computed on a CDC 6400 computer at the University of Minnesota using IMSL subroutine MDSTI.

Critical values for outlier test, α = .05

n / p'	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	20	25	30
6	4.85	6.23	10.89	76.39														
7	4.38	5.07	6.58	11.77	89.12													
8	4.12	4.53	5.26	6.90	12.59	101.9												
9	3.95	4.22	4.66	5.44	7.18	13.36	114.6											
10	3.83	4.03	4.32	4.77	5.60	7.45	14.09	127.3										
11	3.75	3.90	4.10	4.40	4.88	5.75	7.70	14.78	140.1									
12	3.69	3.81	3.96	4.17	4.49	4.98	5.89	7.94	15.44	152.8								
13	3.65	3.74	3.86	4.02	4.24	4.56	5.08	6.02	8.16	16.08	165.5							
14	3.61	3.69	3.79	3.91	4.07	4.30	4.63	5.16	6.14	8.37	16.69	178.2						
15	3.58	3.65	3.73	3.83	3.95	4.12	4.36	4.70	5.25	6.25	8.58	17.28	191.0					
16	3.56	3.62	3.68	3.77	3.87	4.00	4.17	4.41	4.76	5.33	6.36	8.77	17.85	203.7				
17	3.54	3.59	3.65	3.72	3.80	3.90	4.04	4.21	4.46	4.82	5.40	6.47	8.95	18.40	216.4			
18	3.53	3.57	3.62	3.68	3.75	3.83	3.94	4.08	4.26	4.51	4.88	5.47	6.57	9.13	18.93			
19	3.52	3.56	3.60	3.65	3.71	3.78	3.86	3.97	4.11	4.30	4.55	4.93	5.54	6.67	9.30			
20	3.51	3.54	3.58	3.62	3.67	3.73	3.81	3.89	4.00	4.15	4.33	4.59	4.98	5.60	6.76			
21	3.50	3.53	3.57	3.60	3.65	3.70	3.76	3.83	3.92	4.03	4.18	4.37	4.64	5.03	5.67			
22	3.50	3.52	3.55	3.59	3.63	3.67	3.72	3.78	3.86	3.95	4.06	4.21	4.40	4.68	5.08	280.1		
23	3.49	3.52	3.54	3.57	3.61	3.65	3.69	3.75	3.81	3.88	3.98	4.09	4.24	4.44	4.71	21.41		
24	3.49	3.51	3.53	3.56	3.59	3.63	3.67	3.71	3.77	3.83	3.91	4.00	4.12	4.27	4.47	10.07		
25	3.48	3.50	3.53	3.55	3.58	3.61	3.65	3.69	3.73	3.79	3.85	3.93	4.02	4.14	4.30	7.17		
26	3.48	3.50	3.52	3.54	3.57	3.60	3.63	3.66	3.70	3.75	3.81	3.87	3.95	4.05	4.17	5.95		

Table C (continued)

27	3.48	3.50	3.52	3.54	3.56	3.58	3.61	3.65	3.68	3.72	3.77	3.83	3.89	3.97	4.07	5.29	343.8	
28	3.48	3.50	3.51	3.53	3.55	3.58	3.60	3.63	3.66	3.70	3.74	3.79	3.84	3.91	3.99	4.88	23.63	
29	3.48	3.49	3.51	3.53	3.55	3.57	3.59	3.62	3.64	3.68	3.71	3.76	3.81	3.86	3.93	4.61	10.74	
30	3.48	3.49	3.51	3.52	3.54	3.56	3.58	3.60	3.63	3.66	3.69	3.73	3.77	3.82	3.88	4.42	7.53	
31	3.48	3.49	3.50	3.52	3.54	3.55	3.57	3.59	3.62	3.64	3.67	3.71	3.74	3.79	3.84	4.28	6.18	
32	3.48	3.49	3.50	3.52	3.53	3.55	3.57	3.59	3.61	3.63	3.66	3.69	3.72	3.76	3.80	4.17	5.47	407.4
33	3.48	3.49	3.50	3.52	3.53	3.54	3.56	3.58	3.60	3.62	3.64	3.67	3.70	3.74	3.77	4.08	5.03	25.66
34	3.48	3.49	3.50	3.51	3.53	3.54	3.56	3.57	3.59	3.61	3.63	3.66	3.68	3.71	3.75	4.01	4.74	11.34
35	3.48	3.49	3.50	3.51	3.52	3.54	3.55	3.57	3.58	3.60	3.62	3.64	3.67	3.70	3.73	3.96	4.53	7.84
36	3.48	3.49	3.50	3.51	3.52	3.54	3.55	3.56	3.58	3.60	3.61	3.63	3.66	3.68	3.71	3.91	4.37	6.39
37	3.48	3.49	3.50	3.51	3.52	3.53	3.55	3.56	3.57	3.59	3.61	3.62	3.65	3.67	3.69	3.87	4.26	5.62
38	3.48	3.49	3.50	3.51	3.52	3.53	3.54	3.56	3.57	3.58	3.60	3.62	3.64	3.66	3.68	3.84	4.16	5.16
39	3.49	3.49	3.50	3.51	3.52	3.53	3.54	3.55	3.57	3.58	3.59	3.61	3.63	3.65	3.67	3.81	4.09	4.84
40	3.49	3.49	3.50	3.51	3.52	3.53	3.54	3.55	3.56	3.58	3.59	3.60	3.62	3.64	3.66	3.79	4.03	4.62
50	3.51	3.51	3.51	3.52	3.53	3.53	3.54	3.54	3.55	3.56	3.57	3.57	3.58	3.59	3.60	3.66	3.75	3.88
60	3.53	3.53	3.53	3.54	3.54	3.54	3.55	3.55	3.56	3.56	3.57	3.57	3.58	3.58	3.59	3.62	3.67	3.73
70	3.55	3.55	3.55	3.55	3.56	3.56	3.56	3.56	3.57	3.57	3.57	3.58	3.58	3.59	3.59	3.61	3.64	3.67
80	3.57	3.57	3.57	3.57	3.57	3.58	3.58	3.58	3.58	3.58	3.59	3.59	3.59	3.60	3.60	3.61	3.63	3.66
90	3.58	3.59	3.59	3.59	3.59	3.59	3.59	3.60	3.60	3.60	3.60	3.60	3.60	3.61	3.61	3.62	3.63	3.65
100	3.60	3.60	3.60	3.60	3.61	3.61	3.61	3.61	3.61	3.61	3.61	3.62	3.62	3.62	3.62	3.63	3.64	3.65
200	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.74	3.74	3.74	3.74
300	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.82	3.82	3.82	3.82	3.82	3.82	3.82	3.82
400	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
500	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92

Source: Weisberg, S. - 'Applied Linear Regression' (282)

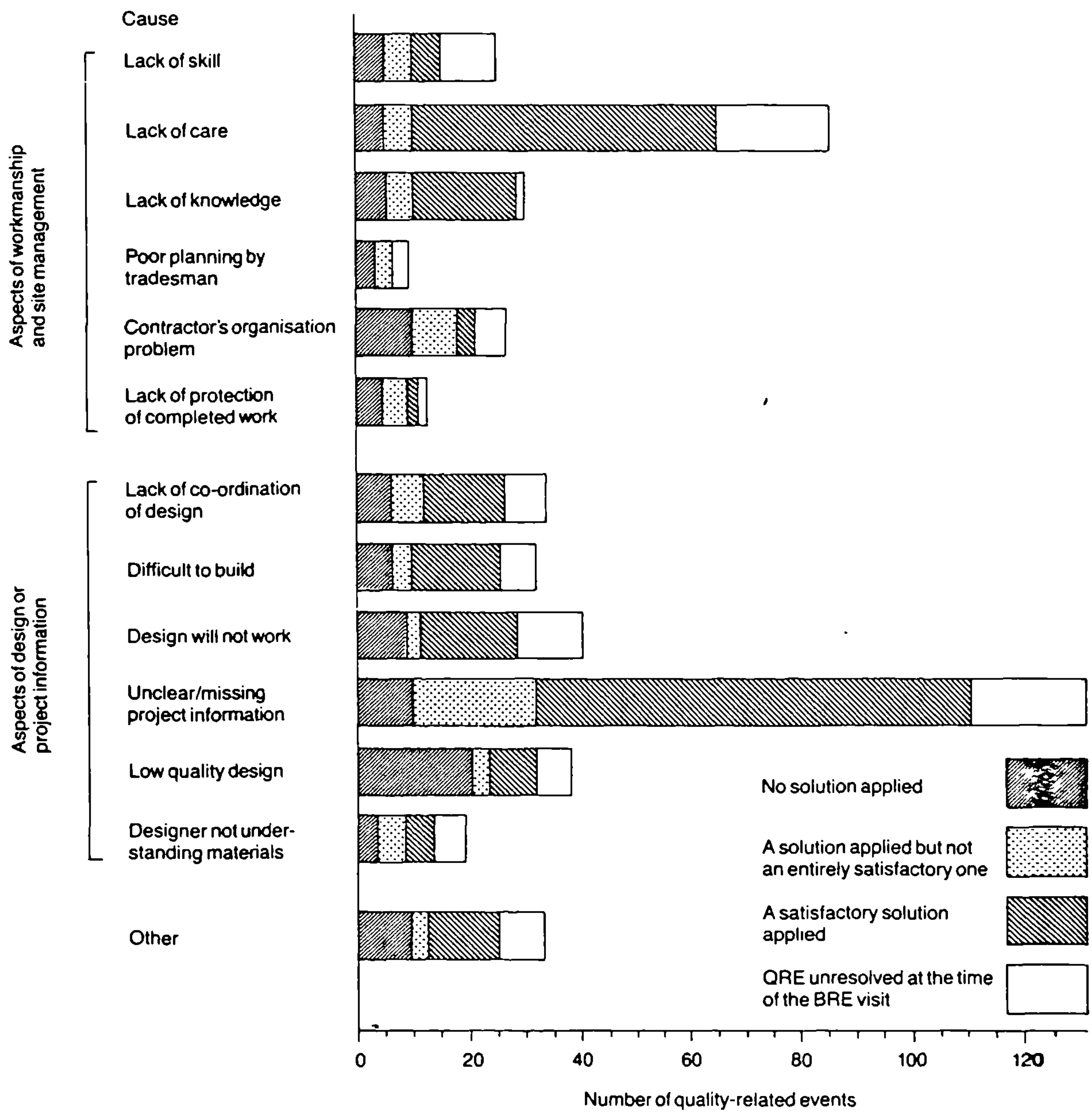
Critical values for outlier test, α = .01

n / p'	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	20	25	30
6	7.53	10.87	24.46	382.0														
7	6.35	7.84	11.45	26.43	445.6													
8	5.71	6.54	8.12	11.98	28.26	509.3												
9	5.31	5.84	6.71	8.38	12.47	29.97	573.0											
10	5.04	5.41	5.96	6.87	8.61	12.92	31.60	636.6										
11	4.85	5.12	5.50	6.07	7.01	8.83	13.35	33.14	700.3									
12	4.71	4.91	5.19	5.58	6.17	7.15	9.03	13.75	34.62	763.9								
13	4.60	4.76	4.97	5.25	5.66	6.26	7.27	9.22	14.12	36.03	827.6							
14	4.51	4.64	4.81	5.02	5.32	5.73	6.35	7.39	9.40	14.48	37.40	891.3						
15	4.44	4.55	4.68	4.85	5.08	5.37	5.80	6.43	7.50	9.57	14.82	38.71	954.9					
16	4.38	4.48	4.59	4.72	4.90	5.12	5.43	5.86	6.51	7.60	9.73	15.15	39.98					
17	4.34	4.41	4.51	4.62	4.76	4.94	5.17	5.48	5.92	6.59	7.70	9.88	15.46	41.21				
18	4.30	4.36	4.44	4.54	4.66	4.80	4.98	5.21	5.53	5.98	6.66	7.80	10.03	15.76	42.41			
19	4.26	4.32	4.39	4.47	4.57	4.69	4.83	5.01	5.25	5.57	6.03	6.72	7.89	10.17	16.05			
20	4.23	4.29	4.35	4.42	4.50	4.60	4.72	4.86	5.05	5.29	5.62	6.08	6.79	7.98	10.31			
21	4.21	4.26	4.31	4.37	4.44	4.52	4.62	4.74	4.89	5.08	5.33	5.66	6.13	6.85	8.06			
22	4.19	4.23	4.28	4.33	4.39	4.46	4.55	4.65	4.77	4.92	5.11	5.36	5.70	6.18	6.91			
23	4.17	4.21	4.25	4.30	4.35	4.41	4.49	4.57	4.67	4.80	4.95	5.14	5.40	5.74	6.22	47.94		
24	4.15	4.19	4.22	4.27	4.32	4.37	4.43	4.51	4.59	4.70	4.82	4.98	5.17	5.43	5.78	17.36		
25	4.14	4.17	4.20	4.24	4.28	4.33	4.39	4.45	4.53	4.62	4.72	4.85	5.00	5.20	5.46	10.92		
26	4.12	4.15	4.18	4.22	4.26	4.30	4.35	4.41	4.47	4.55	4.64	4.74	4.87	5.03	5.23	8.43		

Table C (continued)

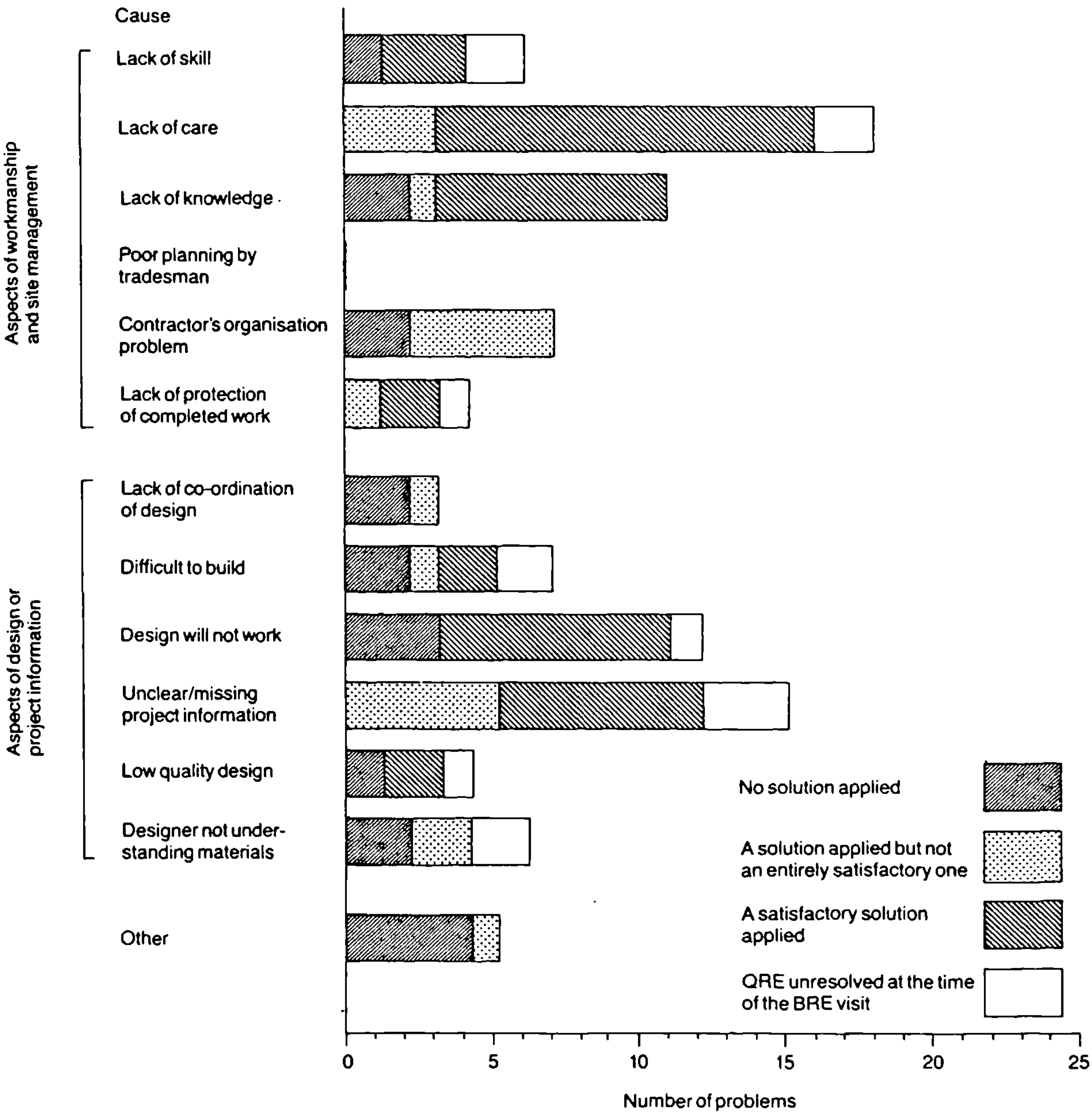
n / p'	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	20	25	30
27	4.11	4.14	4.17	4.20	4.24	4.27	4.32	4.37	4.43	4.49	4.57	4.66	4.76	4.89	5.05	7.17		
28	4.10	4.13	4.15	4.18	4.21	4.25	4.29	4.33	4.38	4.44	4.51	4.59	4.68	4.78	4.91	6.43	52.90	
29	4.09	4.12	4.14	4.17	4.20	4.23	4.26	4.30	4.35	4.40	4.46	4.53	4.60	4.69	4.80	5.94	18.50	
30	4.09	4.11	4.13	4.15	4.18	4.21	4.24	4.28	4.32	4.36	4.42	4.47	4.54	4.62	4.71	5.60	11.44	
31	4.08	4.10	4.12	4.14	4.17	4.19	4.22	4.26	4.29	4.33	4.38	4.43	4.49	4.56	4.64	5.35	8.75	
32	4.07	4.09	4.11	4.13	4.15	4.18	4.21	4.24	4.27	4.31	4.35	4.39	4.45	4.50	4.57	5.16	7.40	
33	4.07	4.08	4.10	4.12	4.14	4.17	4.19	4.22	4.25	4.28	4.32	4.36	4.41	4.46	4.52	5.01	6.60	57.43
34	4.06	4.08	4.09	4.11	4.13	4.15	4.18	4.20	4.23	4.26	4.29	4.33	4.37	4.42	4.47	4.89	6.09	19.51
35	4.06	4.07	4.09	4.11	4.12	4.14	4.16	4.19	4.21	4.24	4.27	4.31	4.34	4.39	4.43	4.79	5.72	11.90
36	4.05	4.07	4.08	4.10	4.12	4.13	4.15	4.18	4.20	4.22	4.25	4.28	4.32	4.36	4.40	4.71	5.46	9.03
37	4.05	4.06	4.08	4.09	4.11	4.13	4.14	4.16	4.19	4.21	4.24	4.26	4.29	4.33	4.37	4.64	5.26	7.60
38	4.05	4.06	4.07	4.09	4.10	4.12	4.13	4.15	4.17	4.20	4.22	4.25	4.27	4.31	4.34	4.59	5.10	6.76
39	4.04	4.06	4.07	4.08	4.10	4.11	4.13	4.14	4.16	4.18	4.21	4.23	4.26	4.28	4.32	4.54	4.97	6.21
40	4.04	4.05	4.06	4.08	4.09	4.10	4.12	4.14	4.15	4.17	4.19	4.22	4.24	4.27	4.29	4.49	4.87	5.83
50	4.03	4.03	4.04	4.05	4.06	4.07	4.07	4.08	4.09	4.10	4.12	4.13	4.14	4.15	4.17	4.25	4.38	4.59
60	4.03	4.03	4.04	4.04	4.05	4.05	4.06	4.06	4.07	4.08	4.08	4.09	4.10	4.11	4.12	4.17	4.23	4.32
70	4.03	4.03	4.04	4.04	4.05	4.05	4.05	4.06	4.06	4.07	4.07	4.08	4.08	4.09	4.09	4.13	4.17	4.22
80	4.04	4.04	4.04	4.05	4.05	4.05	4.06	4.06	4.06	4.07	4.07	4.07	4.08	4.08	4.09	4.11	4.13	4.17
90	4.05	4.05	4.05	4.05	4.06	4.06	4.06	4.06	4.07	4.07	4.07	4.07	4.08	4.08	4.08	4.10	4.12	4.14
100	4.06	4.06	4.06	4.06	4.06	4.07	4.07	4.07	4.07	4.07	4.08	4.08	4.08	4.08	4.09	4.10	4.11	4.13
200	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.16	4.16	4.16
300	4.21	4.21	4.21	4.21	4.21	4.21	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22
400	4.26	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27
500	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31

Figure A **Survey 1: Causes of all 501 quality-related events, and the effectiveness with which they were resolved**



Source: NEDO - 'Achieving Quality on Building Sites' (219)

Figure B **Survey 1: Causes of 98 serious problems identified, and the effectiveness with which they were resolved**



Source: NEDO - 'Achieving Quality on Building Sites' (219)

APPENDIX 1

FINAL SET OF QUESTIONNAIRE

BUILDING

DESIGNER

"QUESTIONNAIRE ONE"

Dear Sir,

Questionnaire Reminder

A questionnaire - Quality of Work in Housing Construction; A Research Project - was forwarded to you a few weeks ago. Your co-operation in the research project would be greatly appreciated. We would be grateful if the questionnaire could be returned to us at your earliest convenience.

Thank You

p.p Professor V.B. Torrance
Head of Department of Building
Heriot-Watt University

Heriot-Watt University
Department of Building

Our Ref: VBT/ACC

Date as postmark

Dear Sir,

Quality of Work in Housing Construction; A Research Project

Various sources have indicated that attainment of acceptable levels of quality in the construction industry has long been a problem. For project quality management to be effective, account must be taken of the distinct parties involved in the building process each with their own particular interests and responsibilities. For the purpose of this study, the parties can be identified as the client who is responsible for defining requirements, the designer (architect) responsible for the design of the building, the assembler (main contractor) responsible for the physical assembly of the building. Another important factor is that for a level of quality to be realised and audited, it must be capable of being defined, assessed, communicated and monitored throughout a building project.

The enclosed questionnaire forms part of the above study currently being undertaken by this Department. It is concerned with the influence of the building designer and building design and specification procedures which have significant influence on quality in construction.

The questionnaire is to be treated in the strictest confidence and the Department wishes to give clear assurance on this aspect of the work.

The value of the study will be considerably increased if you could answer all of the questions as frankly as possible. We are aware of the pressures under which you operate and the time constraints on your work, but I very much hope that a little of your time can be spent on completing the questionnaire. This will assist us greatly in the research project.

Chambers Street, Edinburgh EH1 1HX. Telephone 031-225 8432. **Head of Department** Professor V B Torrance, MSc, Phd, FCIOB, FBIM.

Heriot-Watt University
Department of Building

A stamped, addressed envelope is provided for the return of the questionnaire. We would be grateful if the questionnaire could be returned at your earliest convenience as this will facilitate quick processing.

On behalf of my colleagues I would like to take this opportunity to thank you in anticipation of your assistance.

Yours faithfully,

PROFESSOR V.B. TORRANCE
Head of Department of Building

Chambers Street, Edinburgh EH1 1HX. Telephone 031-225 8432. **Head of Department** Professor V B Torrance, MSc, Phd, FCIOB, FBIM.

0001 1-4

PERSONAL BACKGROUND RECORD 1 5

SECTION A

The following items are concerned with your personal background. For each item please tick appropriate box or write in the space provided.

1. Sex Male 1☐ ☐6
   Female 2☐

2. Age ________________ years ☐7

3. Job Title _____________________ ☐8

4. Highest Qualification attained to date

   (a) Dip. Arch 1☐ ☐9
   (b) B. Arch 2☐
   (c) M.Sc. Arch 3☐
   (d) Other (please specify)____________________ 4☐

5. Are you a member of any professional institution (e.g. RIBA, RIAS, MCIOB, etc.)?

   Yes 1☐ ☐1
   No 2☐

   If answer is 'Yes', name the institution(s)

   ____ ☐1

   give membership grade(s)

6. Experience as a Building Designer

   (a) Less than 2 years 1☐ ☐1
   (b) 2-5 years 2☐
   (c) 5-10 years 3☐
   (d) 10 or more years 4☐

7. How long is your industrial experience in the construction industry to date (inclusive of trainee/apprenticeship experience)?

   approx _____________ years ☐1 1

8. How long have you been employed in your present organisation?

   approx _____________ years ☐1 1

9. Type of Building project undertaken in the field of architecture?

(a) Housing 1☐
(b) Hospitals 2☐
(c) School Building 3☐
(d) Industrial Buildings 4☐
(e) Commercial Buildings 5☐
(f) Other (please specify)__________________ 6☐

10. Do you use RIBA Plan of Work?

Yes 1☐
No 0☐

11. If you do, please indicate the average range in percentage of the time spent for each stage over the total project time.

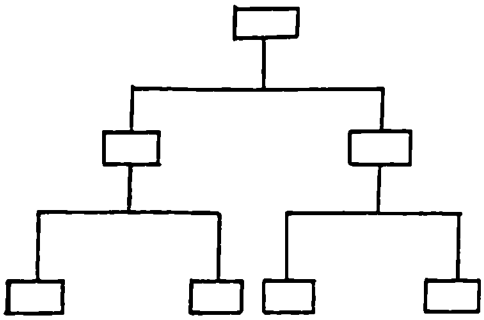
Stage A - Inception ______________
Stage B - Feasibility ______________
Stage C - Outline Proposals ______________
Stage D - Scheme Design ______________
Stage E - Detail Design ______________
Stage F - Production Information ______________
Stage G - Bills of Quantities ______________
Stage H - Tender Action ______________
Stage J - Project Planning ______________
Stage K - Operation on Site ______________
Stage L - Completion ______________
Stage M - Feedback ______________

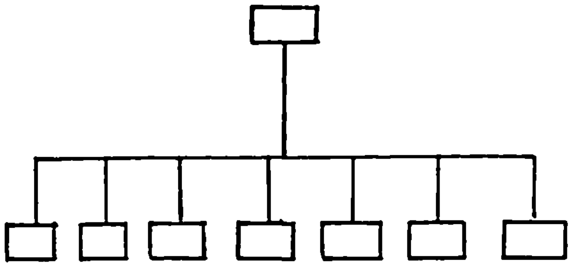
12. Approximate value of work under your control in any one year

(a) Under £100,000 1☐
(b) £100,000 - £250,000 2☐
(c) £250,000 - £500,000 3☐
(d) £500,000 - £1,000,000 4☐
(e) over £1,000,000 5☐

13. Organisational Diagram

Which of the following structures of organisations does your firm fit in, and please indicate the number of people at each level.





Tall ______________________ Flat _________________________

Other (please describe)

SECTION B

The following questions are concerned with your job characteristics such as required skill, task identity, feedback from the job and so on. It is an attempt to tap your perceptions on the job, and there is no right or wrong answer to each item. Please indicate your response by ticking on the arrow on the response scale provided. Please do not omit any of the items.

1. To what extent does your job require you to work with other people (either clients or people in related jobs in your own organisation)? □38

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Very little, dealing with other people is not at all necessary in doing the job			Moderately, some dealing with others is necessary			Very much, dealing with other people is an absolutely essential part of doing the job

2. How much autonomy is there in your job? That is, to what extent does your job permit you to decide on your own how to go about the work? □39

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Very little, the job gives me almost no personal 'say' about how and when the work is done			Moderate autonomy, many things are standardised and not under my control but I can make some decisions about the work			Very much, the job gives me almost complete responsibility for deciding how and when the work is done

3. To what extent does your job involve doing a 'whole' and identifiable piece of work? That is, is the job a complete piece of work that has an obvious beginning and end? Or is it only a small part of the overall piece of work, which is finished by other people? □40

(1)	(2)	(3)	(4)	(5)	(6)	(7)
My job is a tiny part of the overall piece of work			My job is a moderate sized chunk			My job involves doing the whole piece of work

4. How much variety is there in your job? That is, to what extent does the job require you to do many different things at work, using a variety of your skills and talents?

Very little, the job requires me to do the same routine things over and over again			Moderate variety			Very much, the job requires me to do many different things using a no. of different skills and talents
(1)	(2)	(3)	(4)	(5)	(6)	(7)

☐4

5. In general, how significant or important is your job? That is, are the results of your work likely to significantly affect the lives or well-being of other people?

Not very significant, the outcomes of my work are not likely to have important effects on other people			Moderately significant			Highly significant, the outcomes of my work can affect other people in very important ways
(1)	(2)	(3)	(4)	(5)	(6)	(7)

☐42

6. To what extent does doing the job itself provide you with information about your work performance? That is, does the actual work itself provide clues about how well you are doing - aside from any 'feedback' co-workers or supervisors may provide?

Very little, the job itself is set up so I could work without finding out how well I am doing			Moderately, sometimes doing the job provides feedback, sometimes it does not			Very much, the job is set up so that I get almost constant feedback as I work about how well I'm doing
(1)	(2)	(3)	(4)	(5)	(6)	(7)

☐43

7. The job requires me to use a number of complex or high-level skills.

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐44

8. The job requires a lot of co-operative work with other people

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 4:

9. The job is arranged so that I do not have the chance to do an entire piece of work from begining to end (R)

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 4(

10. Just doing the work required by the job provides many chances for me to figure out how well I am doing

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 4;

11. The job is quick, simple and repetitive (R)

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 4

12. The job can be done adequately by a person working alone - without talking or checking with other people (R)

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 4

13. This job is one where a lot of other people can be affected by how well the work gets done

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 5

14. The job denies me any chance to use my personal initiative or judgement in carrying out the work (R)

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 51

15. The job provides me with the chance to completely finish the pieces of work I begin

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 52

16. The job itself provides very few clues about whether or not I am performing well (R)

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 53

17. The job itself is not very signficant or important in the broader scheme of things (R)

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 54

18. The job gives me considerable opportunities for independence and freedom in how I do the work

Very In-Accurate	Mostly In-Accurate	Slightly In-Accurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate

☐ 55

0	0	0	1

1-4

RECORD 2 5

SECTION C

In many Building Projects, the client is often responsible for defining the requirements for the project and often indicates his wishes on the purchasing of construction products to be specified in the contract documents by the commissioned professional consultant designer. The following items are an attempt to obtain data on preference to choice of materials and products by the building clients for their projects. Please indicate against each item on the response scale provided, the extent to which it applies in your work situation.

1. Detail for quality requirements for the products and materials to be specified for the construction project are given in the briefing information by the building cleints.

Always Often Sometimes Seldom Never ☐ 6

2. In defining quality requirements for the building project, the building client indicates long term durability in products and materials to be used in the construction of the building.

Always Often Sometimes Seldom Never ☐ 7

3. In defining quality requirements for the building project, the building client indicates appropriate performance capability of the products and materials to be used in the construction of the building.

Always Often Sometimes Seldom Never ☐ 8

4. In defining quality requirements for the building project, the building client indicates type of finishes to be specified in the construction documents for the project.

Always Often Sometimes Seldom Never ☐ 9

5. In defining quality requirements for the building project, the building client requests the building designer to make maximum use of British Standards and BSI Kitemark in specifying materials and products to be used in the construction of the building

Always Often Sometimes Seldom Never ☐ 10

6. In defining quality requirements for the building project, the building client requests the building designer to make maximum use of British Board of Agrément certified products to be used in the construction of the building.

Always Often Sometimes Seldom Never ☐ 11

7. In defining quality requirements for the building project the building client requests the building designer to make maximum use of products by Firms of Assessed Capability to National Quality Standards.

Always Often Sometimes Seldom Never ☐ 12

8. In defining quality requirements for the building project, the building client requests the building designer to specify products that are both equally suitable in features and in consistency of quality in case of non-certified items.

Always Often Sometimes Seldom Never ☐ 13

9. In defining quality requirements for the building project the building client draws the attention to feedback information from their existing property to eliminate repetition of identifiable defects.

Always Often Sometimes Seldom Never ☐ 14

SECTION D

The following items are an attempt to gauge your assessment of this project in terms of quality of work produced. Please answer as accurately as possible, basing on conformance to the specified requirements in the drawings and specification, the required and acceptable standards of construction.

1. I usually know whether or not quality of work is satisfactory on this project as a whole and as it stands currently.

Disagree Strongly	Disagree	Disagree Slightly	Neutral	Agree Slightly	Agree	Agree Strongly	
							☐ 15

2. I often have trouble figuring out whether this project has acceptable quality of workmanship or poor quality of workmanship.

Disagree Strongly	Disagree	Disagree Slightly	Neutral	Agree Slightly	Agree	Agree Strongly	
							☐ 16

3. Most people on this project have a pretty good idea of how well they are performing their work with regard to quality of workmanship.

Disagree Strongly	Disagree	Disagree Slightly	Neutral	Agree Slightly	Agree	Agree Strongly	
							☐ 17

4. Most people on this project have trouble figuring out whether they are doing a good or bad job with regard to quality of workmanship.

Disagree Strongly	Disagree	Disagree Slightly	Neutral	Agree Slightly	Agree	Agree Strongly	
							☐ 18

CONSTRUCTION SITE

"QUESTIONNAIRE TWO"

PART I

(FOR SITE AGENT/MANAGER)

riot-Watt University
rtment of Building

your ref:

our ref: VBT/AJM

date: 19th February, 1987

Dear Sir,

Quality of Work in Housing Construction; A Research Project

Various sources have indicated that attainment of acceptable levels of quality in the Construction industry has long been a problem. For project quality management to be effective, account must be taken of the distinct parties involved in the building process, each with their own particular interests and responsibilities.

For the purpose of this study, the parties can be identified as the client, who is responsible for defining requirements, the designer (architect) responsible for the design of the building and the assembler (main contractor) responsible for the physical assembly of the building. Another important factor is that for a level of quality to be realised and audited, it must be capable of being defined, assessed, communicated and monitored throughout a building project.

The enclosed questionnaire forms part of the above study currently being undertaken by this Department. It is concerned with the influence of the site agent/manager, the general and assistant general foreman and tradesmen, the site operatives and the clerk of works on the achievement of quality in site construction work.

The questionnaire is to be treated in the strictest confidence and the Department wishes to give clear assurance on this aspect of the work.

The value of the study will be considerably increased if you could answer all the questions as frankly as possible. We are aware of the pressures under which you operate and the time constraints on your work, but I very much hope that a little of your time can be spent on completing the questionnaire. This will assist us greatly with the research project.

Chambers Street, Edinburgh EH1 1HX. Telephone 031-225 8432. **Head of Department** Professor V B Torrance, MSc, Phd, FCIOB, FBIM.

eriot-Watt University
partment of Building

A stamped addressed envelope is provided for the return of the questionnaire. We would be grateful if the questionnaire could be returned at your earliest convenience as this will facilitate quick processing.

On behalf of my colleagues I would like to take this opportunity to thank you in anticipation of your assistance.

Yours faithfully

Professor V.B. Torrance
Head of Department of Building

Chambers Street, Edinburgh EH1 1HX. Telephone 031-225 8432. **Head of Department** Professor V B Torrance, MSc, Phd, FCIOB, FBIM.

SECTION E

PERSONAL BACKGROUND

The following items are concerned with your personnel background. For each item, please tick appropriate box or write in the space provided.

1. Sex — Male 1 / Female 2 — 19

2. Age ____________ Years — 20 21

3. Job Title ____________ — 22

4. Highest Qualification attained to date. — 23

(a)	Craft/trade certificate (please name trade)	1
(b)	O.N.C.	2
(c)	H.N.C.	3
(d)	H.N.D.	4
(e)	Bachelor Degree	5
(f)	Master Degree	6
(g)	Other (please specify)____________	7

5. Are you a member of any professional institution (e.g. CIOB, RICS, RIBA, ICE, RIAS) ?

Yes 1 / No 0 — 24

If answer is 'yes' please name the institution(s)

____________ — 25

give membership grade(s)

6. Experience as a site agent/manager. — 26

(a)	Less than 2 years	1
(b)	2-5 years	2
(c)	5-10 years	3
(d)	10 or more years	4

7. How long is your industrial experience in the Construction industry to-date (inclusive of trainee/apprenticeship experience)?

approx ______________________ years ☐ 27-28

8. How long have you been employed in your present organisation?

approx ______________________ years ☐ 29-30

9. Type of constructional project undertaken in the past? ☐ 31-37

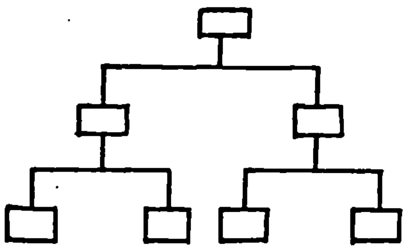
(a) Civil Engineering 1 ☐
(b) Housing Association Project 2 ☐
(c) Local Authority Housing 3 ☐
(d) Private Housing Development 4 ☐
(e) Industrial Building 5 ☐
(f) Commercial Building 6 ☐
(g) Other (please specify) 7 ☐

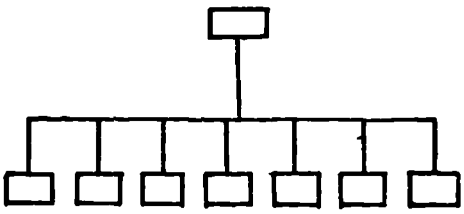
10. Approximate value of work under your control in any one year. ☐ 38

(a) Under £100,000 1 ☐
(b) £100,000 - £250,000 2 ☐
(c) £250,000 - £500,000 3 ☐
(d) £500,000 - £1,000,000 4 ☐
(e) over £1,000,000 5 ☐

11. Organisational Diagram

Which of the following structure of organisation does your company fit in , in terms of Management of Construction site work, and please indicate number of people at each level. ☐ 39-40





Tall ______________________ Flat ______________________

Other (please describe below)

SECTION F

PREAMBLE

Site Collaborative Interpersonal Relationships

The following questions are pairs of statements with which you can describe the degree of site team collaboration that has influence over site work and site organisational effectiveness. The statements refer to various aspects of the work on site such as problem solving through support and integration, open, authenic communication and knowledge-based risk taking. Look at each pair of statements A and B and indicate which is more indicative of your own view of your job situation, by placing a CIRCLE on the appropriate number on the scale provided. If neither statement is applicable place a CIRCLE in the centre point i.e. on number 3.

Example 1

Statement A 1 2 3 4 5 B. Statement
This example shows that your preference is strongly orientated toward Statement A.

Example 2

Statement A 1 2 3 4 5 B. Statement
This example shows that your preference is moderately orientated toward Statement B.

Example 3

Statement A 1 2 3 4 5 B. Statement
This example shows that your preference is for neither statement.

PLEASE ANSWER ALL QUESTIONS

1. When we are working for solutions to task related problems, the site team seems to be most concerned with:

A. Finding the best solution 1 2 3 4 5 B. Whose solution is accepted ☐41

2. The nature of the personal relationships between persons on this site tend to be characterised by:

A. Knowing that others will provide support and encouragement. 1 2 3 4 5 B. Assuming that others will often act to your disadvantage ☐42

3. With respect to the quality objectives of this project, it is probable that individual problem - solving styles will be:

A. Difficult to integrate 1 2 3 4 5 B. Easy to integrate. 43

4. In solving task related problems our site team is satisfied with:

A. Producing acceptable alternatives 1 2 3 4 5 B. Finding the best alternative 44

5. When team members meet or work jointly on problems:

A. They tend to build on each other's ideas 1 2 3 4 5 B. They tend to complete for acceptance on personal ideas 45

6. When a promising but uncertain approach to a problem, the site team:

A. Focuses on the failure 1 2 3 4 5 B. Focuses on learning from the approach 46

7. The way in which our team tries to regulate and tie together its activities is by:

A. A continuous sharing with each other of results on what we are doing 1 2 3 4 5 B. The site agent/ Manager keeping informed and adjusting where needed 47

8. In carrying out our assignment on site work we try to:

A. Act as consultants to each other 1 2 3 4 5 B. Let each man look out for himself 48

9. If someone makes a mistake, other generally:

A. Point out his error and discuss it with him 1 2 3 4 5 B. Avoid drawing attention to it 49

10. When someone among the site workers offers praise or criticism to someone else:

A. You can really believe he means it 1 2 3 4 5 B. You can never quite be sure what he is up to 50

11. When several site workers are discussing an issue:

A. It is best not to say anything that might make one look bad 1 2 3 4 5 B. It is allright to comment or ask questions about anything one doesn't understand 51

12. Our approach to innovation in technique and ways in Construction is:

A. Taking calculated risks — 1 2 3 4 5 — B. Playing it slow and sure. 52

13. In a situation where someone thinks he knows more about an issue than another who has higher rank or status, he would:

A. Argue convincingly and forcefully for his idea — 1 2 3 4 5 — B. State his views and let the other person decide 53

14. In mostly dealings with each other around daily tasks, site construction workers try to:

A. Really accurate as to what they think and feel — 1 2 3 4 5 — B. Keep their thoughts and reactions to themselves 54

15. When we are trying to solve a technical problem the person who has the most to say about its solution is:

A. The one who has the most formal authority — 1 2 3 4 5 — B. The one who has the most knowledge about it as well as ways to solve it 55

16. After a disagreement over how the team should proceed:

A. Those who were in the minority find it difficult to contribute — 1 2 3 4 5 — B. Everyone quickly picks up their part of the task activity 56

SECTION G

The following items are an attempt to guage your assessment of this project in terms of quality of work produced. Please answer as accurately as possible, basing on conformance to the specified requirements in the drawings and specification, the required and acceptable standards of construction.

1. I usually know whether or not quality of work is satisfactory on this project as a whole and as it stands currently.

Disagree Strongly	Disagree	Disagree Slightly	Neutral	Agree Slightly	Agree	Agree Slightly	☐ 57

2. I often have trouble figuring out whether this project has acceptable quality of workmanship or poor quality of workmanship.

Agree Strongly	Agree	Agree Slightly	Neutral	Disagree Slightly	Disagree	Disagree Strongly	☐ 58

3. Most people on this project have a pretty good idea of how well they are performing their work with regard to quality of workmanship.

Disagree Strongly	Disagree	Disagree Slightly	Neutral	Agree Slightly	Agree	Agree Strongly	☐ 59

4. Most people on this project have trouble figuring out whether they are doing a good or a bad job with regard to quality of workmanship.

Agree Strongly	Agree	Agree Slightly	Neutral	Disagree Slightly	Disagree	Disagree Strongly	☐ 60

CONSTRUCTION SITE

"QUESTIONNAIRE TWO"

PART II

(FOR GENERAL FOREMAN, ASSISTANT GENERAL FOREMAN, FOREMAN AND ASSISTANT FOREMAN ONLY)

0	0	0	1	1-4

Record 3 5

SECTION H

The following items are concerned with your brief personal background. For each item, please tick appropriate box or write in the space provided.

1. Age ________________ years ☐ 6

2. Please indicate your position in the site organisational structure.

   (a) Foreman 1☐
   (b) Assistant Foreman 2☐
   (c) General Foreman 3☐
   (d) Assistant General Foreman 4☐

   ☐ 7

3. How long is your industrial experience in the construction industry to date (including trainee/apprenticeship experience)?

   approx __________ years ☐ 8-

4. How much of the above experience is

   Craft/trade related? _______________ years ☐ 10 11

   Managerial/supervisory? ____________ years ☐ 12 13

5. Is site supervision your full-time job?

   Yes 1☐
   No 0☐

   ☐ 14

6. If answer is 'No' please give approximate percentage of time per week spent on:

   Site supervision __________________________________ ☐ 15

   Working as a tradesman/craftsman __________________ ☐ 16

7. On a normal working day, how much of your time is spent in direct contact with site operatives over work-related matters? ☐ 17

1. 0-10%	☐	6. 50-60%	☐
2. 10-20%	☐	7. 60-70%	☐
3. 20-30%	☐	8. 70-80%	☐
4. 30-40%	☐	9. 80-90%	☐
5. 40-50%	☐	10. 90-100%	☐

SECTION I

The following statements are concerned with the frequency you act in your supervisory capacity on site. Please indicate by a tick against arrow on the response scale provided on point which best applies in your work situation on site.

1. Let site operatives know what is expected of them.

Never   Seldom   Occasionally   Often   Always   ☐ 18

2. Encourage the use of situationally determined work procedures

Never   Seldom   Occasionally   Often   Always   ☐ 19

3. Try out your ideas in the group

Never   Seldom   Occasionally   Often   Always   ☐ 20

4. Make your attitudes clear to site operatives

Never   Seldom   Occasionally   Often   Always   ☐ 2

5. Decide what shall be done and how it will be done taking into account the views of site operatives concerned

Never   Seldom   Occasionally   Often   Always   ☐ 2

6. Assign site operatives to particular tasks

Never   Seldom   Occasionally   Often   Always   ☐ 2

7. Make sure that your part in the group is understood by site operatives

Never   Seldom   Occasionally   Often   Always   ☐ 2

8. Schedule site work to be done

Never   Seldom   Occasionally   Often   Always   ☐ 2

9. Maintain definite standards of performance

Never Seldom Occasionally Often Always ☐ 26

10. Ask that group members follow standard rules and regulations

Never Seldom Occasionally Often Always ☐ 27

CONSTRUCTION SITE

"QUESTIONNAIRE TWO"

PART III

FOR SITE OPERATIVES ONLY

SECTION J

The following items are concerned with your general background. Please <u>tick</u> appropriate box or <u>write</u> in the space provided against each item.

1. Sex   Male 1 ☐   28
   Female 2 ☐

2. Age ________________ years   29 30

3. Which craft/trade do you belong to?   31 46

(a) General labourer	1	(i) Plumber	9
(b) Scaffolder	2	(j) Electrician	10
(c) Drainlayer	3	(k) Gas Fitter	11
(d) Steelfixer	4	(l) Painter	12
(e) Bricklayer/blocklayer	5	(m) Plasterer	13
(f) Roofer	6	(n) Floor layer	14
(g) Glazier	7	(o) Wall Tiler	15
(h) Carpenter	8	(p) Other (please specify) ________________	16

4. I am ________ certified skilled craftsman/tradesman 1 ☐   47
   ________ apprentice craftsman/tradesman 2 ☐
   ________ not applicable 3 ☐

5. How long is your trade/craft experience (including your apprenticeship/traineed period)?

approx ________________ years ☐ 48 49

6. How long have you been wokring on this site?

approx ________________ months ☐ 50 51

7. Are you directly employed by: ☐ 52

_____ the main contractor 1 ☐

_____ a subcontractor 2 ☐

_____ not applicable 3 ☐

If answer is not applicable:

(a) Are you self employed?

Yes 1 ☐ No 0 ☐ ☐ 53

(b) Are you a sub-contractor?

Yes 1 ☐ No 0 ☐ ☐ 54

SECTION K

The following statements are concerned with your orientation towards your job on site. There are no right or wrong answers to this questionnaire, for every statement there are large number of people who agree and disagree. Please tick against arrow on response scale provided one point which most closely corresponds to the way which you personally feel.

1. My opinion of myself goes up when I do this job well.

Strongly		Slightly		Slightly		Strongly	55
Disagree	Disagree	Disagree	Neutral	Agree	Agree	Agree	

2. I feel a great sense of personal satisfaction when I do this job well.

Strongly		Slightly		Slightly		Strongly	56
Disagree	Disagree	Disagree	Neutral	Agree	Agree	Agree	

3. I feel bad and unhappy when I discover that I have performed poorly on this job.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 57

4. My own feelings generally are not affected much one way or the other by how well I do on this job (R)

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 58

5. Most people on this job feel a great sense of personal satisfaction when they do the job well.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 59

6. Most people on this job feel bad or unhappy when they find they have performed the work poorly.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

6

0 0 0 1 1-4

RECORD 4 5

SECTION L

The following statements are concerned with the quality of supervision operated on this site. Note that there are no right and wrong answers to this questionnaire, we are interested in the extent of your agreement or disagreement with each item. Please tick against arrow on response scale provided one point which most closely corresponds to your site work situation.

1. My supervisor demands that people give their best effort.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	
							☐ 6

2. My supervisor insists that subordinates work hard.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	
							☐ 7

3. My supervisor demands that subordinates do high quality work.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 8

4. My supervisor keeps informed about the work which is being done

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 9

5. My supervisor plans out work in advance.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 10

6. My supervisor handles the administrative parts of his job extremely well.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 11

7. My supervisor maintains high standards of performance.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

□12

8. My supervisor knows the technical parts of his job extremely well.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

□13

9. My supervisor makes sure subordinates have clear goals to achieve.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

□14

10. My supervisor makes sure subordinates know what has to be done.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 15

11. My supervisor makes it clear how I should do my job.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 16

12. My supervisor helps me solve work-related problems.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 17

13. My supervisor helps me discover problems before they get too bad.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐ 18

14. My supervisor keeps informed about the way subordinates think and feel about things.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐19

15. My supervisor keeps subordinates informed.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐20

16. My supervisor helps subordinates develop their skills.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐21

17. My supervisor has the respect of subordinates.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐22

18. My supervisor deals with subordinates well.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐23

19. My supervisor is always fair to subordinates.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐24

20. My supervisor tends to play favourites (R)

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐25

21. My supervisor encourages subordinates to participate in important decisions.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

☐26

22. My supervisor encourages people to speak up when they disagree with a decision.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

27

23. My supervisor makes most decisions without asking subordinates for their opinions.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

28

24. My supervisor makes important decisions without involving subordinates.

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

29

SECTION M

Please indicate by a tick against arrow on the response scale provided one point which best applies to your site work situation. "Please rate overall supervision in each item".

1. Do you ever have the feeling you would be better off working under different supervision?

I almost always feel this way	I frequently feel this way	I occasionally feel this way	I seldom feel this way	I never feel this way	▯ 30

2. How do you feel about the supervision you receive?

I am extremely satisfied	I am well satisfied	I am only moderately satisfied	I am somewhat dissatisfied	I am very dissatisfied	▯ 31

3. How does the way you are treated by those who supervise you influence your overall attitude toward your job?

It has a very unfavourable influence	It has a slightly unfavourable influence	It has no real influence	It has a favourable influence	It has a very favourable influence

☐ 32

4. How much do the effort of those who supervise you add to the successful achievement of quality in your work?

A very great deal	Quite a bit	Only a little	Very little	Almost nothing

☐ 33

5. The people who supervise me have:

Many more good traits than bad ones	More good traits than bad ones	About the same number of good traits as bad ones	More bad traits than good ones	Many more bad traits than good ones

☐ 34

6. The supervision I receive is the kind that:

Greatly discourages me from giving extra effort	Tends to discourage me from giving extra effort	Has little influence on me	Encourages me to give extra effort	Greatly encourages me to give extra effort

☐ 3

CONSTRUCTION SITE

"QUESTIONNAIRE TWO"

PART IV

FOR THE CLERK OF WORKS ONLY

SECTION N

Personal Background

The following items are concerned with your personal background. For each item, please tick appropriate box or write in the space provided.

1. Sex — Male 1 / Female 2 36

2. Age ______________________ years 37 38

3. Highest qualification attained to date. 39

    (a) Craft/trade certificate (please name trade) 1
    (b) O.N.C. 2
    (c) H.N.C. 3
    (d) H.N.D. 4
    (e) Other (please specify)__________ 5

4. Are you a member of any professional institution (e.g. ICW, CIOB, RICS)?

    Yes 1 40
    No 0

    If answer is 'yes' please name institution(s) 41

    ____
    give membership grade(s)

5. Experience as a Clerk of Works. 42

    (a) Less than 2 years 1
    (b) 2-5 years 2
    (c) 5-10 years 3
    (d) 10 or more years 4

6. How long is your industrial experience in the Construction industry to-date (inclusive of trainee/apprenticeship experience)? 43

    approx. ____________________ years

SECTION P

The following questions are statements concerning the features of your work e.g. responsibilities and workloads you are expected to perform on your job. Please note that there are no right or wrong answers to this questionnaire for there are large number of people with different opinions. Please indicate your response on all the items by ticking (✓) against the arrow on the response scale provided, the extent to which each item applies to your work situation.

How frequently are you bothered at work by:- (for items 1-15).

1. Feeling that you have too little authority to carry out the responsibilities assigned to you.

Never Rarely Sometimes Rather often Nearly all the time ☐ 44

2. Being unclear on just what the scope and responsibilities of your job are.

Nearly All The Time Rather Often Sometimes Rarely Never ☐ 45

3. Not knowing what opportunities for advancement or promotion exist for you.

Never Rarely Sometimes Rather often Nearly all the time ☐ 46

4. Feeling that you have too heavy a workload that you cannot possibly finish during an ordinary day.

Nearly All The Time Rather Often Sometimes Rarely Never ☐ 47

5. Feeling that you are not fully qualified to handle your job.

Never Rarely Sometimes Rather often Nearly all the time ☐ 48

6. Not knowing what your employer thinks of you or how he evaluated your performance.

Nearly All The Time Rather Often Sometimes Rarely Never ☐ 49

7. The fact that you cannot get information to carry out your job.

Never Rarely Sometimes Rather often Nearly all the time ☐ 50

8. Having to decide on things that affect the quality of the completed work on the building on site.

Nearly All The Time — Rather Often — Sometimes — Rarely — Never □ 5

9. Feeling that you may not be liked or accepted by the people you work with.

Never — Rarely — Sometimes — Rather often — Nearly all the time □ 5

10. Feeling unable to influence your employer's or the job architect's or the site agent/manager's decisions and actions that affect the work outcome on site.

Nearly All The Time — Rather Often — Sometimes — Rarely — Never □ 5

11. Thinking that the amount of work you do may interfere with how well it gets done.

Never — Rarely — Sometimes — Rather often — Nearly all the time □ 5

12. Feeling that you have to do things on the job that are against your better judgement.

Nearly All The Time — Rather Often — Sometimes — Rarely — Never □ 5

13. Feeling that your job tends to interfere with your family life.

Never — Rarely — Sometimes — Rather often — Nearly all the time □ 5

14. Not knowing what the people you work with expect of you.

Nearly All The Time — Rather Often — Sometimes — Rarely — Never □ 5

15. Thinking that you will not be able to satisfy the conflicting demands of various people in your job and the demands of your job itself.

Never — Rarely — Sometimes — Rather often — Nearly all the time □ 5

SECTION Q

Listed below are a number of statements concerning your participation in quality control on the site work that eventually emerged. Please read each item and indicate against the arrow in the the response scale provided, the extent to which it applies to your work.

1. I am very clear about the limits of responsibilities in my present job.

Very False	False	Slightly False	Neutral	Slightly True	True	Very True
↑	↑	↑	↑	↑	↑	↑

2. I feel that I always clearly understand what I have to do on my job

Very True	True	Slightly True	Neutral	Slightly False	False	Very False
↑	↑	↑	↑	↑	↑	↑

3. I feel that I am always clear on how I am supposed to do things on my job.

Very False	False	Slightly False	Neutral	Slightly True	True	Very True
↑	↑	↑	↑	↑	↑	↑

4. In general the policies, rules and regulations of the work concerning this project which affect my job are clearly defined.

Very True	True	Slightly True	Neutral	Slightly False	False	Very False
↑	↑	↑	↑	↑	↑	↑

SECTION R

The following items are an attempt to guage your assessment of this project in terms of quality of work produced. Please answer as accurately as possible, basing on conformance to the contract requirements in the drawings and specification, the required and acceptable standards of construction.

1. I usually know whether or not quality of work is satisfactory on this project as a whole and as it stands currently.

Disagree Strongly	Disagree	Disagree Slightly	Neutral	Agree Slightly	Agree	Agree Slightly

2. I often have trouble figuring out whether this project has acceptable quality of workmanship or poor quality of workmanship.

Agree Strongly	Agree	Agree Slightly	Neutral	Disagree Slightly	Disagree	Disagree Strongly

3. Most people on this project have a pretty good idea of how well they are performing their work with regard to quality of workmanship.

Disagree Strongly	Disagree	Disagree Slightly	Neutral	Agree Slightly	Agree	Agree Strongly

4. Most people on this project have trouble figuring out whether they are doing a good or a bad job with regard to quality of workmanship.

Agree Strongly	Agree	Agree Slightly	Neutral	Disagree Slightly	Disagree	Disagree Strongly

APPENDIX 2

INITIAL SET OF QUESTIONNAIRE

BUILDING CLIENT QUESTIONNAIRE;

HOUSING ASSOCIATIONS

ieriot-Watt University
epartment of Building

Our Ref: VBT/ACC

Date as postmark

Dear Sir,

Quality of Work in Housing Construction; A Research Project

Various sources have indicated that attainment of acceptable levels of quality in the construction industry has long been a problem. For project quality management to be effective, account must be taken of the distinct parties involved in the building process each with their own particular interests and responsibilities. For the purpose of this study, the parties can be identified as the client who is responsible for defining requirements, the designer (architect) responsible for the design of the building, the assembler (main contractor) responsible for the physical assembly of the building. Another important factor is that for a level of quality to be realised and audited, it must be capable of being defined, assessed, communicated and monitored throughout a building project.

The enclosed questionnaire forms part of the above study currently being undertaken by this Department. It is concerned with the influence of the officer responsible for building procurement and the management of your new house building project and the inspection of construction work on site by the representative of the owner.

The questionnaire is to be treated in the strictest confidence and the Department wishes to give clear assurance on this aspect of the work.

The value of the study will be considerably increased if you could answer all of the questions as frankly as possible. We are aware of the pressures under which you operate and the time constraints on your work, but I very much hope that a little of your time can be spent on completing the questionnaire. This will assist us greatly in the research project.

Riccarton, Edinburgh EH14 4AS. Tel. 031-449 5111. Fax. 031-449 5153
Head of Department & Professor of Building V B Torrance, BSc, MSc, PhD, FCIOB, FBIM, FRSA
Professor of Building Services Engineering J A Swaffield, BSc, MPhil, PhD, CEng, MRAeS, FIPHE, MCIBSE.

Heriot-Watt University
Department of Building

A stamped, addressed envelope is provided for the return of the questionnaire. We would be grateful if the questionnaire could be returned at your earliest convenience as this will facilitate quick processing.

On behalf of my colleagues I would like to take this opportunity to thank you in anticipation of your assistance.

Yours faithfully,

PROFESSOR V.B. TORRANCE
Head of Department of Building

0 0 0 1
CARD 1

The following questions are concerned with the officer responsible for the procurement of new building projects for the organisation. They are to do with your professional history. Please, do not omit any of the items.

1. Job Title 6

2. Age...............................years 7

3. Qualifications:- 8
   (a) City and Guilds 1
   (b) O.N.C. 2
   (c) H.N.C. 3
   (d) H.N.D. 4
   (e) Degree 5
   (f) Dip.Arch 6
   (g) B.Arch 7
   (h) ARICS 8
   (i) RIBA 9
   (j) MCIOB 10
   (k) Other (please specify) 11

4. Previous Employment.. 9

5. Experience on your previous employment 10
   (a) Less than 2 years 1
   (b) 2-5 years 2
   (c) 5-10 years 3
   (d) 10 or more years 4

6. Construction Industry
   How long have you worked in the construction industry? ....years 11 -

7. Present employment
   How long have you been employed in your present organisation? ....years 13 -

8. Type of constructional project you have had handled in the past. 15 - 21
   (a) Civil Engineering 1
   (b) Housing projects 2
   (c) Industrial building 3
   (d) Commercial building 4
   (e) School buildings 5
   (f) Refurbishment 6
   (g) Other (please specify) 7

9. Approximate value of work under your control in any one year. 22
   (a) Under £100,000 1
   (b) £100,000 - £250,000 2
   (c) £250,000 - £500,000 3
   (d) £500,000 - £1,000,000 4
   (e) Over £1,000,000 5

10. Organisational Diagram

Please draw a schematic diagram of the organisational structure of your Housing Association and the number of people at each level.

☐☐ 23 - 24

he following questions are to assist in understanding the management of our Housing Association (H.A.) particularly with regard to new building rojects. Please indicate against each item the extent to which it applies o your H.A.

Kind of homes provided by your Housing Association.

(a)	Housing for the elderly	1	25-32
(b)	Housing for the physically disabled	2	
(c)	Single people dwellings	3	
(d)	Family housing	4	
(e)	Housing for mentally ill people	5	
(f)	Housing for mentally handicapped	6	
(g)	Shared accomodation and hostels	7	
(h)	Other (please specify)	8	

Financial support for your building projects.

(a)	Apply to Housing Corporation	1	33-36
(b)	Apply to Local Authority	2	
(c)	Support from own resources	3	
(d)	Other (please specify)	4	

ART I BRIEFING

	Never	Seldom	Sometimes	Often	Always	
Current operations of the association and the association waiting list is part of the the criteria used to choose type of Housing development needs to cater for your housing project.	____	____	____	____	____	37-41
Effective space utilisation is part of the criteria used to choose type of Housing development needs to cater for your housing project.	____	____	____	____	____	
The Local Authority housing plans are part of the criteria used to choose type of Housing development needs to cater for your housing project.	____	____	____	____	____	
Local planning authority requirements are part of the criteria used to determine type of housing development needs to cater for your housing project.	____	____	____	____	____	
The controls operated by financing authority form part of the criteria used to choose type of Housing development needs to cater for your housing project.	____	____	____	____	____	

	Never	Seldom	Sometimes	Often	Always	
My Housing Association briefs the architect/ engineer in a booklet form with regard to requirements for the housing project.	____	____	____	____	____	☐ 42-!
My Housing Association briefs the architect/ engineer via a series of letters with regard to requirements for the housing project.	____	____	____	____	____	☐
0. My Housing Association jointly decide on the brief with the consultant with regard to requirements for the housing project.	____	____	____	____	____	☐
1. It is important that in the preparation of the brief the housing mix i.e. type and size of the dwelling units to be built on the site are clearly stated, I make sure this is clearly specified in our new project.	____	____	____	____	____	☐
2. The essential element of the brief to the design team includes a social brief indicating how and by whom the project is to be used.	____	____	____	____	____	☐
3. The essential element of the brief to the design team includes a statement of the desired activities and functions and the relationships between them, I make sure that this is noted in our new project.	____	____	____	____	____	☐
4. The essential element of the client's brief to the design team includes a statement of the required timing of the project and an assessment of the consequences of failure to meet time targets, this is included in our new project.	____	____	____	____	____	☐
5. The essential element of the brief to the design team includes a statement of the expected budget restraints, which are likely to be determined by cost limits, this is stated in our new project.	____	____	____	____	____	☐
6. It is important to concentrate upon the essential operational services in the building in the formation of the brief; this aspect is covered in our new housing project.	____	____	____	____	____	☐

Never Seldom Sometimes Often Always

17. It is important to concentrate upon the quality of the building finishes in the formation of the brief, this aspect is covered in our new project. ____ ____ ____ ____ ____ ☐

5

18. Continuity of demand for a building type enable the briefing process to be simplified by reference to similar projects and experiences thereon (e.g. on specification of materials, products, components, etc.) ____ ____ ____ ____ ____ ☐

19. Getting a good brief depends in part on systematically building up knowledge about the user's requirements, and I make a conscious effort generally toward that end. ____ ____ ____ ____ ____ ☐

20. The briefing, if carried out early and formally removes a large element of uncertainty from a project, I am alert to this aspect in our new project. ____ ____ ____ ____ ____ ☐

21. A client's brief may be subsequently modified after detailed discussion with the designer, and chance given to the designer to find creative solutions for a particular site, this is considered in our new housing project. ____ ____ ____ ____ ____ ☐

PART II APPOINTMENT OF CONSULTANT

22. Do you have an in-house designer for all or most of your new building projects? ☐

Yes	1
No	0

If No please go to Questions 23-30.

23. In choosing a consultant designer, it is of vital importance to quality management in construction to consider experience on details of type and size of work normally undertaken by the practice, this is practiced in our new project. ____ ____ ____ ____ ____ ☐

24. In choosing a consultant designer, it is of vital importance to quality management in construction to consider senior people in charge - names and experiences of partners and senior staff to be allocated to the project, this is considered in our new project. ____ ____ ____ ____ ____ ☐

	Never	Seldom	Sometimes	Often	Always
25. In choosing a consultant designer, it is of vital importance to quality management in construction to consider management procedures in the office practice - methods used to control project co-ordination, timetables, costs and quality of work; this effort is consciously made to that end in our new project.					
26. In choosing a consultant designer, it is of vital importance to quality management in construction to consider facilities for members of the design team to work in close collaboration with one another and the client body, particularly in relation to the geographical location of the members of the design team, the client and the site, this effort is made in our new project.					
27. In choosing a consultant designer, it is pretty important to quality management in construction to consider references - the names of other clients for whom similar projects and the quality of work, the consultant have undertaken, this is practiced in our new project.					
28. Careful selection procedures will ensure that the experience of the consultant will be properly matched to the technical complexity of a particular project, and this effort is made generally to that end in our new project.					
29. It is vital for quality management in construction to require the consultant to submit an outline specification in order to study the proposed materials, components and form of construction before the final drawings are approved, this is consciously practiced in our new project.					
30. It is an important consideration that if the design of a project has been carried out by a consultant, the consultant is required to brief in-house staff who are to supervise/ inspect the work on site, this is practiced in our new project.					

	Never	Seldom	Sometimes	Often	Always	
PART III APPOINTMENT OF CONTRACTOR						
The procedure used in our new project to select the main contractor is by:-						
31. Open competition.	___	___	___	___	___	☐ 65-70
32. Select competition.	___	___	___	___	___	☐
33. Negotiation	___	___	___	___	___	☐
34. Two-stage tender.	___	___	___	___	___	☐
35. Serial/continuity tender.	___	___	___	___	___	☐
36. Other (please specify)	______________________					☐
In selecting the main contractor for our new project it is important to consider:-				0 0 0 1 CARD 2		1 - 4 :5
37. Numbers and categories of Supervisory Staff and permanently employed operatives of the contractor.	___	___	___	___	___	☐ 6 - 12
38. Trades normally sub-contracted by the main contractor.	___	___	___	___	___	☐
39. Work in which the firm specialises.	___	___	___	___	___	☐
40. Details of current contracts.	___	___	___	___	___	☐
41. Were payments to sub-contractors and supplies made regularly?	___	___	___	___	___	☐
42. Was site performance to programme and the quality of work?	___	___	___	___	___	☐

PART IV PROJECT TEAM

43. Do you always have a project team that is responsible for the building project from the design stage to construction and completion of the building?

Yes [1]
No [0]

☐

	Never	Seldom	Sometimes	Often	Always
Project team members for our new building project include:-					
44. An Architect					
45. Structural Engineer					
46. Services Engineer					
47. Quantity Surveyor					
48. Main Contractor					
49. Development Officer/Manager					
50. Building Officer/Manager					
51. Clerk of Works					
52. Other (please specify)					
How do you ensure that the various team members are conscious of quality when producing information or in the course of their work?					
53. By prescribing their individual and collective responsibilities at the out-set.					
54. By establishing a communication system for the team.					
55. By allowing normal working practices form the teams working environment.					
Our main concern about quality in new building project is principally to do with:-					
56. Functional effectiveness.					
57. Quality of materials and components.					
58. Durability					
59. Aesthetic delight.					
60. Performance without excessive maintenance costs.					
61. Excellent finishes.					

62. Longevity and adaptability. ___ ___ ___ ___ ___ 32

Do you want the result of the study.

YES/NO

Please make any comment on the questionnaire.

The following questions are concerned with the Clerk of Works or Staff responsible for control of quality of construction work on site on behalf of the client. There are five responses possible to each item. This allows you to express the degree of agreement or disagreement with the item. The five responses are:-

SA - Strongly Agree
A - Agree
N - Neutral Opinion
D - Disagree
SD - Strongly Disagree

Please answer all questions by circling your response to each item. (Please, the Clerk of Works should answer these questions).

It is important to quality management in construction to study the contract documents (e.g. drawings and specifications) in order to be conversant with the design assumptions and other parameters affecting the construction for some 2-3 weeks before the start of work on site, as this will assist the Clerk of Works in his duties on site.	SA	A	N	D	SD	☐ 33-4:
It is pretty important to quality management in construction for the Clerk of Works to meet the job Architect for some discussion and briefing on the job before the start of work on site.	SA	A	N	D	SD	☐
It is very important to quality management in construction to have a well prepared inspection brief produced either by the design team or the client or the Clerk of Works when inspecting Contractor's work on site.	SA	A	N	D	SD	☐

The steps taken to identify those features that need particular attention and inspection of work during construction must include:-

Drawing checklist after studying drawings and specifications for the particular project.	SA	A	N	D	SD	☐
Discussion with the client.	SA	A	N	D	SD	☐
Discussion with the job architect for the project.	SA	A	N	D	SD	☐
Careful observation on site.	SA	A	N	D	SD	☐

The dominant factors to be considered for the degree and frequency of inspection of work during construction must include:-

Size of the project.	SA	A	N	D	SD	☐
Technical complexity of project.	SA	A	N	D	SD	☐

42-5

10. Type of contract. SA A N D SD

11. Speed of construction. SA A N D SD

12. "Your other comments..................................

....

The steps to be taken by the Clerk of Works to overcome problems encountered by the contractor due to inadequate or poor project information provided by the designer in contract documents include:-

13. To consult the job architect/engineer. SA A N D SD

14. To produce sketch/design details to support the project information. SA A N D SD

15. To insist on the job architect/engineer to visit the work on site frequently. SA A N D SD

16. "Your other comments"................................

....

If it has been discovered that the contractor's work on site does not comply with the contract documents and consequently will affect the quality of work in the finished building, the Clerk of Works must take steps to:-

17. Draw the attention of the site agent to remove or remedy defective work. SA A N D SD

18. Identify the causes of the problem and advice the agent as appropriate. SA A N D SD

19. Have frequent and regular informal discussion on the problem with the staff working on site. SA A N D SD

20. "Your other comments"................................

....

If the contractor persistently fails to comply, the Clerk of Works should take other action to solve the problem including:-

21. Advice the architect/engineer-in-charge of the circumstances in writing. SA A N D SD

22. Advice the client to get involved. SA A N D SD

23. Send a well descriptive and meaningful report on the problem to the client. SA A N D SD

24. "Your other comments"...............................

.... 56–62

The following technical reference books/papers are very useful for site inspection guide and assist the Clerk of Works in controlling quality of construction work on site:-

25. Greater London Council Clerk of Works Handbook.	SA	A	N	D	SD
26. Building Research Establishment Site Checklists.	SA	A	N	D	SD
27. Building Research Establishment, Building Defects Action Sheets.	SA	A	N	D	SD
28. National House Building Council Registered House Builders Site Manual.	SA	A	N	D	SD
29. Institute of Electrical Engineers 15th Edition Services Booklet.	SA	A	N	D	SD
30. Scottish Gas Board Inspector's Manual.	SA	A	N	D	SD

Do you want the result of the study.

YES/NO

Please make any comments on the questionnaire.

CONSULTANT BUILDING DESIGNER

QUESTIONNAIRE

eriot-Watt University
partment of Building

your ref:

our ref: HS/ACC

Date as postmark

Dear Sir,

Quality of Work in Housing Construction

Due to increasing numbers of defective or otherwise faulty works in construction and the high costs of maintenance and repair work in housing, it is intended to explore the ways by which quality (necessary standards) in construction could be improved.

The enclosed questionnaire forms part of the study undertaken by the department. It is concerned with building design and specification procedures which have significant influence on quality in construction.

The questionnaire is to be treated in the strictest confidence and the Department wishes to give clear assurance on this aspect of the work.

The value of the study will be considerably increased if you could answer all of the questions as frankly as possible.

We are aware of the pressures under which you operate and the time constraints on your work, but I very much hope that a little of your time can be spent on the questionnaire. This will assist us greatly in the research study.

A stamped, addressed envelope is enclosed for the return of the questionnaire. We would be grateful if the questionnaire could be returned at your earliest convenience as this will facilitate quick processing.

Chambers Street, Edinburgh EH1 1HX. Telephone 031-225 8432. Head of Department Professor V B Torrance, MSc, Phd, FCIOB, FBIM.

I would like to take this opportunity to thank you, in anticipation of your assistance.

Yours faithfully,

PROFESSOR V.B. TORRANCE
Head of Department of Building

Encl.

Chambers Street Edinburgh EH1 1HX Telephone 031-225 8432 Head of Department Professor V B Torrance MSc Phd FCIOB FBIM

0	0	0	1

1 - 4

CARD 3 5

The following statements are concerned with your professional history. Please do not omit any of the items.

1. Job Title.. 6

2. Age..............................years 7-8

3. Qualifications:- 9

   (a) Dip. Arch. 1
   (b) B. Arch. 2
   (c) M.Sc. Arch 3
   (d) RIBA 4
   (e) Other (please specify) 5

4. Experience as a Building Designer 10

   (a) Less than 2 years 1
   (b) 2-5 years 2
   (c) 5-10 years 3
   (d) 10 or more years 4

5. Construction Industry
   How long have you worked in the construction industry?

   ....years 11 -

6. Present Employment
   How long have you been employed in your present organisation?

   ....years 13-1

7. Type of project undertaken in the field of architecture. 15-21

   (a) Housing 1
   (b) Hospitals 2
   (c) School Buildings 3
   (d) Industrial buildings 4
   (e) Commercial buildings 5
   (f) Refurbishment 6
   (g) Other (please specify) 7

8. Do you use RIBA Plan of Work? 22

   Yes 1
   No 0

9. If you do, please indicate the average range in percentage the time spent for each stage over the total project time. 23-33

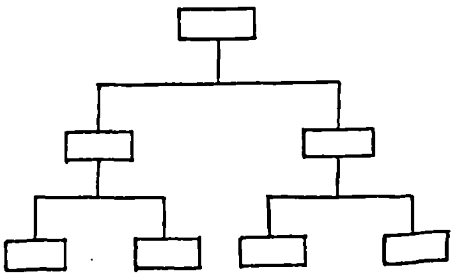
Stage A - Inception ______
Stage B - Feasibility ______
Stage C - Outline proposals ______
Stage D - Scheme design ______
Stage E - Detail design ______
Stage F - Production information ______
Stage G - Bill of Quantities ______
Stage H - Tender Action ______
Stage J - Project planning ______
Stage K - Operation on site ______
Stage L - Completion ______
Stage M - Feed-back ______

10. Approximate value of work under your control in any one year. 34

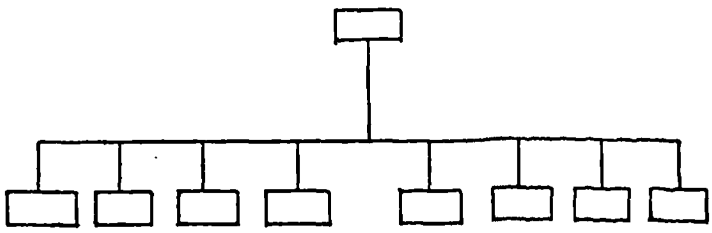
(a) Under £100,000 1
(b) £100,000 - £250,000 2
(c) £250,000 - £500,000 3
(d) £500,000 - £1,000,000 4
(e) Over £1,000,000 5

11. Organisational Diagram

Which of the following structure of organisation does your company fit in, and please indicate the number of people at each level. 35-37



Tall ______



Flat ______

Other (please describe)

The following questions are concerned with some Architects Design Procedures (with respect to sketch and detail drawings) which have significant influence on quality of work in construction. Please Indicate your response against each item, the extent to which it applies to your design work.

	Never	Seldom	Sometimes	Often	Always	
Making a comprehensive site investigation in order to get accurate information on location, dimensions, and contours of the site for your new design and on the position of any existing features and services that may affect or be affected by the new construction is of vital importance to quality management in construction, and I try to keep that purpose clearly in mind before the start of design.						☐ 38 43
How often does the client require an appraisal and recommendation so that he may determine the form in which the project is to proceed ensuring that it is feasible functionally, technically and financially.						☐
How often are you allowed sufficient time and resources within an appopriate design budget to enable for complete and thorough project information to be prepared before tendering procedures and before start of construction?						☐
The choice of details which avoid conflict between very accurate components and relatively inaccurate surrounding construction is important consideration in a proposed design work, I take notice of that as I design.						☐
How frequently do you choose details which facilitate the adjustment of continuous elements in relation to structural frames?						☐
Designing types of joints (where accumulated inaccuracies from adjacent construction have to be absorbed, and where potential problems of fit have to be resolved) which will accommodate variability should be taken care of in a proposed design, I practice that in my design work.						☐

Never Seldom Sometimes Often Always

	Never	Seldom	Sometimes	Often	Always	
Identifying and treating separately, some joints that may be required to permit and subsequent differential movement after construction, and provide range of movement within the joints is of vital importance to quality management in construction, I make effort toward that end in my design work.	___	___	___	___	___	□ 44-49
Discussing with client, the relationship of constructional detail to the structural, and service systems in the building project so as to invite other professional consultants in order to add their expertise to the early sketch details and outline specification stage could contribute to avoidance of abortive work, I make effort toward that end in my design work.	___	___	___	___	___	□
Problems of accessibility to design information (e.g. BSI Codes, Standards, advisory documents and reports etc) in design work could bring delay in design programmes, and I take note of that in my deisgn work.	___	___	___	___	___	□
I am aware that the contractor will normally give "currently accepted good practice" in construction for items that have not been specified in detail, and I make sure that sufficient information is provided in the working drawings.	___	___	___	___	___	□
Making substantial assessment of quality and value during the design process in order to balance one attribute against another, and in investigating alternative ways of achieving them is of vital importance to quality management in construction, and I make effort toward that end in my design work.	___	___	___	___	___	□
Making a final critical appraisal of constructional details in drawings, before issuing the drawings to the quantity surveyor for Bills preparation and to the contractor for tendering could aid to spot mistakes, and I try to do that in my design work.	___	___	___	___	___	□

	Never	Seldom	Sometimes	Often	Always

3. Is your design freedom constrained by:-

   (a) Client's resources [1]
   (b) Legal requirements (e.g. building regulations, codes, planning legislations, etc). [2]
   (c) Lack of time to re-appraise designs before going to tender [3]
   (d) All of the above [4]
   (e) None of the above [5]

4. To consider the principles of function, fit, practicality, maintenance and costs in the choice of materials and components during development of sketch details in design is of vital importance to quality management in construction, and I make a conscious effort to that end in my design work. ____ ____ ____ ____ ____

5. Meeting with technical representatives of manufacturers of materials and components during the development of sketch details into working drawings in order to discuss the choice on materials and components on their suitability, performance, assembly and fixing is an important aid to quality management in construction, and I keep that in mind in my design work. ____ ____ ____ ____ ____

6. Working drawings finally checked by a more senior architect before being despatched to site is important to quality management in construction, this is practiced in my office. ____ ____ ____ ____ ____

7. The use of models in new design work as a communication medium could enhance clarity of information, and I produce such models in my design work. ____ ____ ____ ____ ____

50
5

he following questions are concerned with some Architect's Design rocedures with respect to specification writing which have some influence n quality of work in construction. Please indicate your response against ach item, the extent to which it applies in your design work.

	Never	Seldom	Sometimes	Often	Always	
To have ready access to information sources relating to Building Standards, Codes, Regulations, products and materials for specification writing in design is of vital importance to quality management in construction, and I make sure that required information is always available in my design work.						5 6
Seeking confirmation of test results of (critical items) products which are claimed by manufacturers that they conform with BSs is important to quality management in construction, and I try to confirm any information I am in doubt.						
Choice of products which I have used before or which had been used by others for reasonable time for specification writing in new design work is preferred, so I feel perfectly at ease when specifying materials in that line.						
I believe that manufacturers give <u>adequate</u> information on their products.						
I believe that manufacturers give <u>clear</u> information on their products.						
I believe that manufacturers give accurate information on their products.						
Specifications are open to more than one interpretation, and I try to write clear, unambiguous information in my design work.						
I believe that the areas of specifications relating to the building standards, codes, regulations are fully understood by designers.						
Which of these areas create(s) most of the problem(s) if any?						
. I believe that specifiers ask for higher quality of work than could be reasonably expected.						

	Never	Seldom	Sometimes	Often	Always	
1. I believe that project supervisors ask for higher quality of workmanship than asked for by the specification.	___	___	___	___	___	6
2. My organisation operate						
(a) a standard specification	___	___	___	___	___	
(b) a one-off for each job	___	___	___	___	___	
(c) a standard specification modified for each job	___	___	___	___	___	
				0 0 0 1 CARD 4		1 - 4 5
3. There is tendency to specify too much about "how things should be done" and not enough about what is required in the end product by many building designers, and I try to avoid that in my design work.	___	___	___	___	___	6
4. I consult Agreément Certificates for information.	___	___	___	___	___	
5. I find the certificates useful.	___	___	___	___	___	
6. I would like to see the wider use of these certificates.	___	___	___	___	___	
7. I study the National Building Specification (NBS)	___	___	___	___	___	
8. I consider it useful.	___	___	___	___	___	
9. I consider it workable.	___	___	___	___	___	
10. I use NBS in designing projects.	___	___	___	___	___	
11. I find it time consuming.	___	___	___	___	___	
12. I find it time saving.	___	___	___	___	___	

13. Where would you look for information on:

(a) Products?	1
(b) Standards?	2
(c) Tolerances?	3
(d) Workmanship?	4

14. Where do you suppose the specification be put?

(a) on the drawings?	5
(b) in the Bills of Quantities	6
(c) in a separate book	7
(d) other (please specify)	8

The following questions are to assess the pattern of work in architectural offices. There are five responses possible to each item. This allows you to express the degree of agreement or disagreement with the item. The five responses are:-

SA - Strongly agree
A - Agree
N - Neutral opinion
D - Disagree
SD - Strongly disagree

Please answer all questions by circling your response to each item.

1. Building designer's predominant activities include drawing, preparing reports and correspondences, meetings and discussions; drawing time decreases as designer's responsibilities increase. SA A N D SD ☐ 24-32

2. Outline concept of a design is usually produced by an experienced architect after personal contact with the Client, and the more detailed refinement of designs are often carried out by junior, less experienced, designers who may not have contact with the Client. SA A N D SD ☐

3. Time scales rarely allow exploration of alternative concepts in designs. SA A N D SD ☐

4. Most designers have the tendency to work on several projects at a time. SA A N D SD ☐

5. Incomplete briefing information by the Client at an early stage of design could complicate the design and even cause abortive work. SA A N D SD ☐

6. Factors such as budget, project programming and site constraints may have significant influences on design decision making. SA A N D SD ☐

7. Building designers have the tendency not to record the progress of their designs in detail in their projects at hand. SA A N D SD ☐

8. Building designers find it difficult to plan their workloads in advance due to external influence, e.g. short notice of new commissions (jobs) by another Client. SA A N D SD ☐

9. There is a tendency by designers to avoid official literature in their design work unless it is absolutely necessary, e.g. Building Regulations and associated data, etc. SA A N D SD ☐

10. Experience acquired through the practice of design tend to be used more in design decision making. SA A N D SD ☐ 33 42

11. Ease of communication within an architectural office will aid exchange of experience and accessibility to information for design decision making and drawings. SA A N D SD ☐

12. Architects tend to value verbal contact between colleagues more as a quicker way of gaining information and sharing experience than consulting written design data. SA A N D SD ☐

13. In most architectural offices, there is never time enough for drawings and other work of more junior staff to be checked by Senior Architects. SA A N D SD ☐

14. Design, programmes, usually delayed due to length of time negotiating for and obtaining statutory approvals from appropriate authorities could cause a large proportion of design time to be consumed. SA A N D SD ☐

15. In a design work situation if designers can progress smoothly without interruption, the quality of design is likely to be improved. SA A N D SD ☐

16. There is need to increase designer's awareness of the need to consult written information as well as awareness of information itself. SA A N D SD ☐

17. Most architectural offices do not possess library of current British Standards, manufacturers literature, and other related documents for the office practice, as keeping good library tends to be costly. SA A N D SD ☐

18. The introduction of uniformally fair competition between architectural offices will go a long way to provide adequate levels of quality in designs. SA A N D SD ☐

19. The British Standards and other Building Regulations demand for only minimum standards to be achieved in construction. SA A N D SD ☐

The following questions are statements that may or may not be true for your job situation in your office practice or department. Please indicate for each item, the extent to which it applies.

	Definately False	False	True	Definately True	
1. To achieve separation of information between drawings and specifications, it is important to develop technical detailing and specification writing in parallel.	____	____	____	____	☐ 43 50
2. Quality of design cannot be assured without expressing the requirements about means, methods and systematic manner to be used for the design work.	____	____	____	____	☐
3. Taking a lot of care about all important and tricky details in design work, is vital in producing required information in the working drawings.	____	____	____	____	☐
4. Design-review-checklists used in my work always assist in detecting weak points in desi gn, e.g. for crucial quality characteristics which require increased data and information.	____	____	____	____	☐
5. All aspects which may affect the quality of information in contract documents (e.g. arrangement of all set of drawings systematically to avoid co-ordination faults) are closely examined before finally passed to site.	____	____	____	____	☐
6. I always produce site plan, general elevations, general sections, floor plans, main construction details and special components as minimum tender drawings in my design work.	____	____	____	____	☐
7. One of the job-architects influence on quality of construction work is through specification briefing of clerk of works before work starts on site.	____	____	____	____	☐
8. I use numerical criteria - such as cost per unit area, to make substantial assessment of quality and cost in my design work, bearing in mind the cost yardstick/indicative cost provided by my Client.	____	____	____	____	☐

	Definately False	False	True	Definately True
9. I use breakdown of construction costs to main elements of the building to make substantial assessment of quality and cost in my design work, bearing in mind the cost yardstick/indicative cost provided by my Client.				
10. I use performance attributes which affect the operational efficiency of the building to make substantial assessment of quality and cost in my design work, bearing in mind the cost yardstick/indicative cost provided by my Client.				
11. I use appearance and amenity attributes which are largely the Client's decision and matter of judgement to make substantial assessment of quality and cost in my design work bearing in mind the cost yardstick/indicative cost provided by my Client.				
12. I use photographs and models as a communication medium in my design work.				
13. I usually visit the works on site during the main phases of construction and write down possible improvements for future design work.				

5

Do you want the results of the study.

YES/NO

Please make any comments on the questionnaire.

SITE AGENT/MANAGER

QUESTIONNAIRE

Heriot-Watt University
Department of Building

Our Ref: VBT/ACC

Date as postmark

Dear Sir,

Quality of Work in Housing Construction; A Research Project

Various sources have indicated that attainment of acceptable levels of quality in the construction industry has long been a problem. For project quality management to be effective, account must be taken of the distinct parties involved in the building process each with their own particular interests and responsibilities. For the purpose of this study, the parties can be identified as the client who is responsible for defining requirements, the designer (architect) responsible for the design of the building, the assembler (main contractor) responsible for the physical assembly of the building. Another important factor is that for a level of quality to be realised and audited, it must be capable of being defined, assessed, communicated and monitored throughout a building project.

The enclosed questionnaire forms part of the above study currently being undertaken by this Department. It is concerned with the influence of the site agent/manager, standard of workmanship and on site and general site management during construction.

The questionnaire is to be treated in the strictest confidence and the Department wishes to give clear assurance on this aspect of the work.

The value of the study will be considerably increased if you could answer all of the questions as frankly as possible. We are aware of the pressures under which you operate and the time constraints on your work, but I very much hope that a little of your time can be spent on completing the questionnaire. This will assist us greatly in the research project.

A stamped, addressed envelope is provided for the return of the questionnaire. We would be grateful if the questionnaire could be returned at your earliest convenience as this will facilitate quick processing.

Chambers Street, Edinburgh EH1 1HX. Telephone 031-225 8432. Head of Department Professor V B Torrance, MSc, Phd, FCIOB, FBIM.

On behalf of my colleagues I would like to take this opportunity to thank you in anticipation of your assistance.

Yours faithfully,

PROFESSOR V.B. TORRANCE
Head of Department of Building

Chambers Street, Edinburgh EH1 1HX. Telephone 031-225 8432. **Head of Department** Professor V B Torrance, MSc, Phd, FCIOB, FBIM.

The following statements are concerned with your professional history. Please do no omit any of the items.

55

1. Job Title..

2. Age...............................years 56-5

3. Qualifications:- 58.

(a)	Trade apprenticeship (Please name trade)	1
(b)	City and Guilds	2
(c)	O.N.C.	3
(d)	H.N.C.	4
(e)	H.N.D.	5
(f)	Degree	6
(g)	L.C.I.O.B.	7
(h)	M.C.I.O.B.	8
(k)	Other (please state)	9

4. Experience as a site agent (please tick) 59

(a)	Less than 2 years	1
(b)	2-5 years	2
(c)	5-10 years	3
(d)	10 or more years	4

5. Construction Industry
How long have you worked in the construction industry?

...............years 60-6

6. Present employment
How long have you been employed in the your present organisation?

...............years 62-

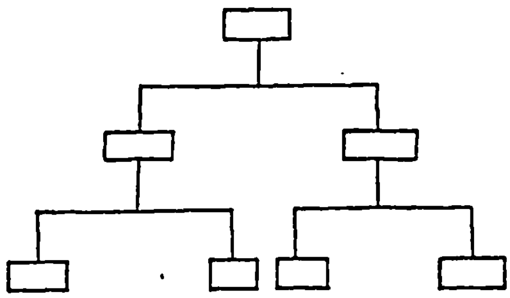
7. Type of constructional project undertaken in the past (please tick) 64-70

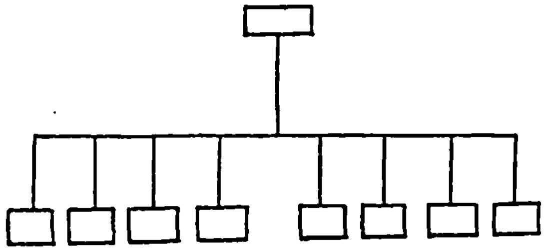
(a)	Civil Engineering	1
(b)	Housing Association project	2
(c)	Local Authority Housing	3
(d)	Industrial Building	4
(e)	Commercial Building	5
(f)	Refurbishment	6
(g)	Other (please specify)	7

8. Approximate value of work under your control in any one year. 6

(a) Under £100,000 1
(b) £100,000 - £250,000 2
(c) £250,000 - £500,000 3
(d) £500,000 - £1,000,000 4
(e) Over £1,000,000 5

9. Organisational Diagram
Which of the following structure of organisation does your company fit in, in terms of site management of construction, and please indicate no of people at each level. 7-9





Tall ____________ Flat ____________

Other (please describe)

The following questions are concerned with the importance of communications upon the quality of work attained on site. Please indicate, against each item, the extent to which it applies in your place of work.

1. How much time did you spend to study contract documents (e.g. drawings and specifications) on your current project prior to commencing work on site?

   (a) None [1] 10
   (b) Less than one week [2]
   (c) Less than two weeks [3]
   (d) More than two weeks [4]

2. Do you have for your own use on site the following?

   (a) Specification [1] 11-1
   (b) Bill of Quantitites [2]
   (c) Drawings [3]
   (d) Programmes [4]

3. Do you have for your own use on site current British Standards and Codes of Practice?

   (a) None [1] 15
   (b) 1-5 [2]
   (c) 5-10 [3]
   (d) More than 10 [4]

4. Please name the British Standards and Codes of Practice you use currently for reference.

   (a) BS Handbook No. 3 (Summaries of British Standards for Building, including Code of Practice). [1] 16-2
   (b) BSI Yearbook 1983 [2]
   (c) BS 5606: 1978 Code of Practice for Accuracy in Building [3]
   (d) All the above [4]
   (e) Other (please specify) [5]

5. Do you have for your own use on site other essential documents applicable to the work in hand (e.g. BRE digests, leaflets and other publications)?

   (a) Yes [1] 21
   (b) No [0]

6. How you do instruct your supervisors with regards to specified requirements?

(a) In writing [1]
(b) Verbally [2]
(c) When requested [3]
(d) Help themselves from documents available. [4]

[ ] 22
[ ] 25
[ ]
[ ]

7. How does information form the architect/supervising officer reach you?

(a) Direct [1]
(b) Via Head or other Office [2]

[ ] 26

8. Does your company possess a library of current British Standards, Codes of Practice, Manufacturers Liteature?

(a) Yes [1]
(b) No [2]
(c) Don't Know [3]

[ ] 27

9. To what extent do you consider that communication contributes to the quality of the finished building?

(a) None [1]
(b) Little [2]
(c) A lot [3]

[ ] 28

10. What information do you use most on site to carry out your work between:-

(a) Project drawing [1]
(b) Bill of Quantities [2]
(c) Specifications [3]
(d) Project drawings and specification [5]

[ ] 29

11. Do you keep a fully described drawing register that indicates the latest drawing from the job architect or structural/services engineer?

Yes/No [1] [0]

[ ] 30

e following questions are concerned with the motivation of site workers wards quality of work obtained on site. Please indicate against each em to which it applies in your work situation on site.

	Never	Seldom	Sometimes	Often	Always	
Using social skills (including persuading, negotiating, informal discussion, encouraging and counselling) to get workers to understand, accept and act upon information concerning the production of the building on site is important in motivating workers, and I make some effort toward that end.	____	____	____	____	____	☐ 31 37
Using position power (the right to give orders, control progress, inspect work, etc) to get workers to understand, accept and act upon information concerning the production of the building on site is important in motivating workers, and I make effort toward that end.	____	____	____	____	____	☐
It is important to consider quality of craftsmen, e.g. training and experience when assigning job to operatives, I am aware of this and look for the right people for any job at hand.	____	____	____	____	____	☐
Lack of co-operation between staff on site may affect the achievement of satisfactory quality end result in construction work and I encourage operatives to work in a warm close fashion with each other.	____	____	____	____	____	☐
The ultimate quality of work may depend on the match between operative and task and I make effort toward that end when assigning job to my staff on site.	____	____	____	____	____	☐
It is possible to face problem of unacceptable quality of finish or dimension arising mainly from lack of skill and requiring the work to be repeated, I am aware of this and try to avoid it in my work on site.	____	____	____	____	____	☐
Lack of care by operative could cause problem of quality - completed work not to standard as required I am aware of this and try to encourage adequate supervision of work on site.	____	____	____	____	____	☐

Never Seldom Sometimes Often Always

It is possible to encounter quality control problem when nominated subcontractors are employed on site and I encourage close co-ordination and consultation between my firm and subcontractor's work on site. _____ _____ _____ _____ _____ ☐ 38-47

It is possible to encounter quality control problem when subcontractor (labour-only) is employed on site and I make effort to take the management of subcontractor's operatives as part of my duty on site. _____ _____ _____ _____ _____ ☐

0. It is important to get the job 'right the first time' and I encourage the operatives to discourse on any information they are in doubt on site. _____ _____ _____ _____ _____ ☐

1. I consider interest and pride as an important characteristic of a person who consistently produces above average quality work on site. _____ _____ _____ _____ _____ ☐

2. I consider high standard of personal conduct to be an important characteristic of a person who consistently produces above average quality work on site. _____ _____ _____ _____ _____ ☐

3. I consider proper training as an important characteristic of a person who consistently produces above average quality of work on site. _____ _____ _____ _____ _____ ☐

4. I consider experience to be an important characteristic of a person who consistently produces above average quality of work on site. _____ _____ _____ _____ _____ ☐

5. Does the use of example (demonstration) encourage your men to be quality conscious in the course of their work on site? _____ _____ _____ _____ _____ ☐

6. Does adequate and tight supervision encourage your men to be quality conscious in the course of their work on site? _____ _____ _____ _____ _____ ☐

7. Does financial incentive encourage your men to be quality conscious in the course of their work on site? _____ _____ _____ _____ _____ ☐

Never Seldom Sometimes Often Always

18. Does condemnation of poor workmanship encourage your men to be quality conscious in the course of their work on site? ____ ____ ____ ____ ____ ☐

19. Does compliment of good workmanship encourage your men to be quality conscious in the course of their work on site? ____ ____ ____ ____ ____ ☐

20. Does your company employ finishing foreman, in order to ensure that poor workmanship or bad materials are spotted on time and corrected? ____ ____ ____ ____ ____ ☐

The following questions are to assess the effectiveness of site management in construction work on the site. There are five possible responses to each item. This allows you to express the degree of agreement or disagreement with the item.
The five responses are:-

SA	-	strongly agree
A	-	agree
N	-	neutral opinion
D	-	disagree
SD	-	strongly disagree

Please answer all questions by circling your response to each item.

1. Adequate number of staff and an appropriate organisational structure should be recognised by site management, to deal with both production targets and quality control. SA A N D SD ☐ 51-59

2. It is necessary for site management to delegate areas of responsibility to appropriate persons, due to the demand of the building process on site. SA A N D SD ☐

3. A site agent dealing with subordinates does not only have direct lines of communication, but must deal with the interrelationships between all the subordinates. SA A N D SD ☐

4. Education and enlightment of staff and subcontractors should be a prime objective of the site manager. SA A N D SD ☐

5. A separate quality control personnel or finishing foreman will free the site manager from part of the day-to-day activities and ensure that poor workmanship are spotted at an early stage and corrected. SA A N D SD ☐

6. Good supervision at the correct time is the key to achieving good standards throughout the building process on site. SA A N D SD ☐

7. In addition to general observations of work, site management should systematically check each day all work which has been carried out. SA A N D SD ☐

8. To improve the quality of construction work, it is of utmost importance to identify critical phases of the project in the course of planning and execution. SA A N D SD ☐

9. There is an optimistic expectation that quality of work on the site can be improved by motivation provided that individual personality in the process of construction work is sufficiently regarded. SA A N D SD ☐

10. Main causes of errors and defective work could be reduced to human insuffiency as ignorance, carelessness and negligence. SA A N D SD ☐ 60-(

11. Poor storage, handling and protection of components on site are the major causes of loss of performance in those components. SA A N D SD ☐

12. Lack of care in installation and inadequate protection of materials and products at the stage of construction frequently causes problems of poor quality in the building finally. SA A N D SD ☐

13. Sound detailing and specification could go ahead in solving most of the problems site management encounters on projects and as a means of achieving quality control in building contracts. SA A N D SD ☐

14. There is a pressing need to improve the motivation of site workers towards quality. SA A N D SD ☐

15. Recording "quality problems" of work encountered in construciton on a daily basis will go a long way in avoiding similar incidence in the future. SA A N D SD ☐

16. Reviewing the total operations on site periodically to look at each section of the project in order to identify "quality problem" areas will help the site management to produce first class job at the end of the day. SA A N D SD ☐

17. Protecting completed work before moving to the next stage or closing for the day will assist to avoid abortive work and enhance the quality of the job. SA A N D SD ☐

18. It is quite vital for site management to determine from the design information whether or not work departs from the design intentions. SA A N D SD ☐

19. It is very important for the site management to avoid financial crisis in order to avoid leaving work standing on site, open to the weather, for a long period of time. SA A N D SD ☐

Do you want the results of the study

YES/NO

Please make any comments on the questionnaire

APPENDIX 3

FACTOR ANALYSIS OF STANDARDISED SCALES

HACKMAN AND OLDHAM'S [140] CORE JOB DIMENSION SCALES

The dimensionality of measures of perceived job characteristics and worker reactions to them have been popular research areas (e.g. Brief and Aldag [47], Hackman and Oldham [140], Dunham [110], Dunham [111], Oldham et al [224], and Hackman and Lawler [142]). The objective of much recent research in this area has been to understand and document the manner in which workers respond to a set of job characteristics. The issue that is addressed in this section of the thesis is the understanding of job design construct and the dimensionality of measures of perceived job characteristics.

Based on prior exploratory research on the factor structure of the above scales, the present study included the three items forming each scale designed to assess the six priori job descriptive constructs. The analysis classified each of the three items into orthogonal factors. A single factor structure was extracted with eigen values greater than one; as indicated by the computer printouts for each scale. The present study is in agreement with the hypothesised scale structure outlined by Hackman and Oldham's [140] prior constructs. The discussion of the relationships among the a priori constructs in Hackman and Oldham [140, p.166] indicates they believed the scales were not strongly intercorrelated. The extent of intercorrelation among the building design setting scales in this research is indicated in Table 20.

Perusal of the table shows that the scales are moderately intercorrelated. It could be deduced that, the moderate level of intercorrelation among the scales does not detract from their usefulness as separate job dimensions.

The scales were factor analysed and the results are shown in the following pages:

1. Required Skill (SKVRT): The three items forming this scale were factor analysed and the analysis classified the items into orthogonal factors. A single factor structure was extracted accounting for 64.8% of the total variance with eigen value of 1.95.

2. Task Identify (TASKID): A single factor was extracted from the items forming this scale and the percentage of variance stands at 54.2% with eigen value of 1.63.

3. Task Significance (TASKSG): The three items forming this scale were factor analysed and a single factor was extracted accounting for 53.0% of the total variance with eigen value of 1.59.

4. Job Autonomy (AUTO): Similarly, a single factor was extracted from the items forming this scale and the total variance stands at 57.5% with eigen value of 1.73.

5. Feedback from the Job (FEEDBC): The three items forming this scale were factor analysed and a single factor was finally extracted, accounting for 55.4% of the total variance with eigen value of 1.66.

6. Dealing with Client and Others (DEALC): The three items forming this scale were factor analysed and a single factor was finally extracted accounting for 57.1% of the total variance with eigen value of 1.71.

Sims et al [252] conducted a study that investigated a revised version of the Hackman and Oldham [140] job characteristics instruments. Factor analyses were conducted on the items from five core dimensions plus a dimension on friendship opportunities. Sims et al [252] concluded that a six-factor solution was the most readily interpretable and meaningful factor structure for each scale. Table D.1 shows the item loadings from the result of the research. There is a similarity on the item loadings as reported in this research.

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SKVRT1	1.00000	*	1	1.94517	64.8	64.8
SKVRT2	1.00000	*	2	.64833	21.6	86.4
SKVRT3	1.00000	*	3	.40650	13.6	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
SKVRT2	.85233
SKVRT1	.82860
SKVRT3	.72947

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SKVRT1	.68659	*	1	1.94517	64.8	64.8
SKVRT2	.72646	*				
SKVRT3	.53212	*				

REPRODUCED CORRELATION MATRIX:

	SKVRT1	SKVRT2	SKVRT3
SKVRT1	.68659*	-.11677	-.21957
SKVRT2	.70624	.72646*	-.18697
SKVRT3	.60444	.62174	.53212*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 3 (100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0>WARNING 11310
>Only one factor was extracted. The solution cannot be rotated.

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
TASKID1	1.00000	*	1	1.62555	54.2	54.2
TASKID2	1.00000	*	2	.77655	25.9	80.1
TASKID3	1.00000	*	3	.59790	19.9	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
TASKID2	.79520
TASKID3	.72925
TASKID1	.67926

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
TASKID1	.46140	*	1	1.62555	54.2	54.2
TASKID2	.63234	*				
TASKID3	.53181	*				

REPRODUCED CORRELATION MATRIX:

	TASKID1	TASKID2	TASKID3
TASKID1	.46140*	-.21476	-.26750
TASKID2	.54015	.63234*	-.20087
TASKID3	.49535	.57990	.53181*

OTHE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 3 (100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATIO

0>WARNING 11310
>*Only one factor was extracted. The solution cannot be rotated.*

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
TASKSG1	1.00000	*	1	1.59139	53.0	53.0
TASKSG2	1.00000	*	2	.81836	27.3	80.3
TASKSG3	1.00000	*	3	.59025	19.7	100.0

PC EXTRACTED 1 FACTORS.

- F A C T O R A N A L Y S I S - - - - -

FACTOR MATRIX:

	FACTOR 1
TASKSG2	.80698
TASKSG3	.69213
TASKSG1	.67907

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
TASKSG1	.46113	*	1	1.59139	53.0	53.0
TASKSG2	.65121	*				
TASKSG3	.47905	*				

REPRODUCED CORRELATION MATRIX:

	TASKSG1	TASKSG2	TASKSG3
TASKSG1	.46113*	-.20627	-.28820
TASKSG2	.54799	.65121*	-.20429
TASKSG3	.47001	.55854	.47905*

THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 3 (100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

>WARNING 11310
>Only one factor was extracted. The solution cannot be rotated.

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1
TASKSG1	.42671
TASKSG2	.50709
TASKSG3	.43492

```
EXTRACTION  1  FOR ANALYSIS  1, PRINCIPAL-COMPONENTS ANALYSIS (PC)


INITIAL STATISTICS:

VARIABLE      COMMUNALITY  *  FACTOR    EIGENVALUE    PCT OF VAR    CUM PCT
                           *
AUTO1             1.00000  *     1        1.72572        57.5          57.5
AUTO2             1.00000  *     2         .72153        24.1          81.6
AUTO3             1.00000  *     3         .55276        18.4         100.0
0   PC EXTRACTED    1 FACTORS.

FACTOR MATRIX:

               FACTOR  1

AUTO3            .80995
AUTO1            .74647
AUTO2            .71588



FINAL STATISTICS:

VARIABLE      COMMUNALITY  *  FACTOR    EIGENVALUE    PCT OF VAR    CUM PCT
                           *
AUTO1              .55721  *     1        1.72572        57.5          57.5
AUTO2              .51249  *
AUTO3              .65602  *

REPRODUCED CORRELATION MATRIX:

                  AUTO1        AUTO2        AUTO3

AUTO1            .55721*     -.25348      -.18404
AUTO2            .53438       .51249*     -.19728
AUTO3            .60460       .57983       .65602*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX;  THE
 DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN
 THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

 THERE ARE    3 ( 100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05


 VARIMAX   ROTATION  1  FOR EXTRACTION  1  IN ANALYSIS  1 - KAISER NORMALIZATIO

0>WARNING 11310
 >Only one factor was extracted.  The solution cannot be rotated.
```

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
FEEDBC1	1.00000	*	1	1.66087	55.4	55.4
FEEDBC2	1.00000	*	2	.83504	27.8	83.2
FEEDBC3	1.00000	*	3	.50409	16.8	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
FEEDBC2	.84311
FEEDBC1	.71793
FEEDBC3	.65925

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
FEEDBC1	.51543	*	1	1.66087	55.4	55.4
FEEDBC2	.71084	*				
FEEDBC3	.43461	*				

REPRODUCED CORRELATION MATRIX:

	FEEDBC1	FEEDBC2	FEEDBC3
FEEDBC1	.51543*	-.17313	-.30630
FEEDBC2	.60529	.71084*	-.18127
FEEDBC3	.47330	.55582	.43461*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 3 (100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION

0>WARNING 11310
>Only one factor was extracted. The solution cannot be rotated.

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
DEALC1	1.00000	*	1	1.71160	57.1	57.1
DEALC2	1.00000	*	2	.74673	24.9	81.9
DEALC3	1.00000	*	3	.54167	18.1	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
DEALC3	.81166
DEALC2	.76640
DEALC1	.68223

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
DEALC1	.46544	*	1	1.71160	57.1	57.1
DEALC2	.58737	*				
DEALC3	.65880	*				

REPRODUCED CORRELATION MATRIX:

	DEALC1	DEALC2	DEALC3
DEALC1	.46544*	-.25474	-.20878
DEALC2	.52286	.58737*	-.17550
DEALC3	.55374	.62206	.65880*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 3 (100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0>WARNING 11310
>Only one factor was extracted. The solution cannot be rotated.

Table D.1 Factor Loadings for Job Characteristics Scales (Sims et al [252])

Scale/Items		Loadings
Skill Variety		
Items	1	.69
	2	.62
	3	.72
Job Autonomy		
Items	1	.57
	2	.64
	3	.46
Feedback from the Job		
Items	1	.69
	2	.84
	3	.59
Task Identity		
Items	1	.50
	2	.72
	3	.71
Dealing with Others		
Items	1	.78
	2	.68
	3	.42
Friendship		
Items	1	.39
	2	.67
	3	.61

ARAM ET AL'S [8] TEAM COLLABORATIVE INTERPERSONAL RELATIONSHIP SCALES

A factor analysis was undertaken on the above scales as follows:

1. Problem Solving through Support and Integration (PSSINT): As indicated from the computer printouts 2 Factors were extracted from the six items forming this scale. Factor 1 is formed by items 2, 4 and 6; and accounted for 30.3% of the total variance, with eigen value of 1.82. Factor 2 is formed by items 1, 3 and 5 and accounted for 23.8% of the total variance with eigen value of 1.43. All the items were pure on each factor.

2. Open, Authentic Communication (OPAUC): As indicated from the computer printouts 2 Factors were extracted from the five items forming this scale. Factor 1 is formed by items 2, 4 and 5 and accounted for 31.7% of the total variance, with eigen value of 1.59. Factor 2 is formed by items 1 and 3, and accounted for 22.3% of the total variance with eigen value of 1.11. All the items were pure on each factor except item 3 which loads in 2 rotated factors. But looking at the unrotated factor matrix, all the items appeared to be pure on each factor.

3. Knowledge-Based Risk Taking (KBRST): Two factors were similarly extracted from the four items forming this scale. Factor 1 is formed by items 1 and 3 and accounted for 29.9%

of the total variance with eigen value of 1.19. Factor 2 is formed by items 2 and 4, and accounted for 26.6% of the total variance with eigen value of 1.06. All the items were pure on each factor except item 2 which loads on the 2 rotated factors. The scale needs to be modified.

The total Factor Structure for the team collaboration scales was not reported by Aram et al [8]. Only item loadings were indicated in the report. The item loadings for each of the scales reported in this research were greatly similar to those reported by Aram et al [8] as shown in Table D.2. It is considered that the questionnaire pertaining to these scales is satisfactory from theoretical and pragmatic viewpoints. The extent of intercorrelations among the scales is shown in Table 23.

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
PSSINT1	1.00000	*	1	1.81630	30.3	30.3
PSSINT2	1.00000	*	2	1.42882	23.8	54.1
PSSINT3	1.00000	*	3	.97471	16.2	70.3
PSSINT4	1.00000	*	4	.68028	11.3	81.7
PSSINT5	1.00000	*	5	.61128	10.2	91.9
PSSINT6	1.00000	*	6	.48860	8.1	100.0

0 PC EXTRACTED 2 FACTORS.

FACTOR MATRIX:

	FACTOR 1	FACTOR 2
PSSINT6	.69027	-.34521
PSSINT2	.65635	-.37245
PSSINT4	.53708	-.49637
PSSINT5	.54955	.58342
PSSINT1	.38190	.57577
PSSINT3	.41561	.50381

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
PSSINT1	.47735	*	1	1.81630	30.3	30.3
PSSINT2	.56951	*	2	1.42882	23.8	54.1
PSSINT3	.43655	*				
PSSINT4	.53484	*				
PSSINT5	.64122	*				
PSSINT6	.59565	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0 VARIMAX CONVERGED IN 3 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2
PSSINT6	.76159	.12502
PSSINT2	.75007	.08307
PSSINT4	.72611	-.08724
PSSINT5	.10374	.79401
PSSINT1	-.02817	.69033
PSSINT3	.04132	.65180

FACTOR TRANSFORMATION MATRIX:

	FACTOR 1	FACTOR 2
FACTOR 1	.81012	.58627
FACTOR 2	-.58627	.81012

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1	FACTOR 2
PSSINT1	-.06591	.44972
PSSINT2	.44557	.00060
PSSINT3	-.02135	.41900
PSSINT4	.44322	-.10807
PSSINT5	.00613	.50761
PSSINT6	.44953	.02708

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
OPAUC1	1.00000	*	1	1.58735	31.7	31.7
OPAUC2	1.00000	*	2	1.11407	22.3	54.0
OPAUC3	1.00000	*	3	.98543	19.7	73.7
OPAUC4	1.00000	*	4	.70928	14.2	87.9
OPAUC5	1.00000	*	5	.60387	12.1	100.0

0 PC EXTRACTED 2 FACTORS.

FACTOR MATRIX:

	FACTOR 1	FACTOR 2
OPAUC5	.75220	.26423
OPAUC2	-.70975	.18015
OPAUC4	.61370	-.06050
OPAUC3	-.27435	.74894
OPAUC1	-.25675	-.66876

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
OPAUC1	.51316	*	1	1.58735	31.7	31.7
OPAUC2	.53619	*	2	1.11407	22.3	54.0
OPAUC3	.63617	*				
OPAUC4	.38029	*				
OPAUC5	.63562	*				

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2
OPAUC5	.74235	.29076
OPAUC2	-.71569	.15484
OPAUC4	.61546	-.03867
OPAUC3	-.30076	.73872
OPAUC1	-.23285	-.67745

FACTOR TRANSFORMATION MATRIX:

	FACTOR 1	FACTOR 2
FACTOR 1	.99937	.03550
FACTOR 2	-.03550	.99937

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1	FACTOR 2
OPAUC1	-.14033	-.60565
OPAUC2	-.45258	.14573
OPAUC3	-.19659	.66569
OPAUC4	.38830	-.04054
OPAUC5	.46515	.25384

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
KBRST1	1.00000	*	1	1.19467	29.9	29.9
KBRST2	1.00000	*	2	1.06411	26.6	56.5
KBRST3	1.00000	*	3	.89666	22.4	78.9
KBRST4	1.00000	*	4	.84457	21.1	100.0

0 PC EXTRACTED 2 FACTORS.

FACTOR MATRIX:

	FACTOR 1	FACTOR 2
KBRST1	.71687	.08172
KBRST3	-.69701	.20072
KBRST4	-.22242	.76377
KBRST2	.38140	.65863

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
KBRST1	.52058	*	1	1.19467	29.9	29.9
KBRST2	.57925	*	2	1.06411	26.6	56.5
KBRST3	.52612	*				
KBRST4	.63282	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0 VARIMAX CONVERGED IN 3 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2
KBRST3	-.71161	.14045
KBRST1	.70727	.14266
KBRST4	-.28684	.74198
KBRST2	.32374	.68880

FACTOR TRANSFORMATION MATRIX:

	FACTOR 1	FACTOR 2
FACTOR 1	.99634	.08542
FACTOR 2	-.08542	.99634

Table D.2 Factor Loadings for Team Collaboration Scales (Aram et al [8])

Scale/Item		Item Loadings
Problem Solving through Support and Integration		
Items	1	.78
	2	.75
	3	.70
	4	.70
	5	.64
	6	.64
Open, Authentic Communication		
Items	1	.78
	2	.73
	3	.60
	4	.59
	5	.51
Knowledge-based risk taking		
Items	1	.79
	2	.62
	3	.48
	4	.44

STOGDILL'S [260] INITIATING STRUCTURE SCALE (INST)

A factor analysis was undertaken on the above scale. Three factors were extracted from the total 10 items forming this scale. Factor 1 is formed by items 3, 8 and 10, and accounted for 33.6% of the total variance with eigen value of 3.36. Factor 2 is formed by items 1, 2, 4 and 6 and accounted for 16.4% of the total variance with eigen value of 1.64. Factor 3 is formed by items 5, 7 and 9 and accounted for 11.6%. Factor 1 is concerned with schedule of work, Factor 2 is concerned with operative performance and Factor 3 is concerned with definitive standards to be achieved.

However, the factor structure is complex with a number of items loading on more than one factor and considered as impure items. These items are 2, 6, 7 and 10. Supervisor initiating structure is a complex phenomenon and empirical overlap among the items is to be expected. However, some normative information on the scale is available as reported by Cook et al [86], and there is extensive evidence documenting good reliability across a wide range of samples. Reliability coefficients of 0.61 (pretest data) and 0.76 (main data) were obtained in this study.

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
INST1	1.00000	*	1	3.36181	33.6	33.6
INST2	1.00000	*	2	1.63691	16.4	50.0
INST3	1.00000	*	3	1.16231	11.6	61.6
INST4	1.00000	*	4	.90968	9.1	70.7
INST5	1.00000	*	5	.73267	7.3	78.0
INST6	1.00000	*	6	.66998	6.7	84.7
INST7	1.00000	*	7	.54994	5.5	90.2
INST8	1.00000	*	8	.39637	4.0	94.2
INST9	1.00000	*	9	.32262	3.2	97.4
INST10	1.00000	*	10	.25772	2.6	100.0

0 PC EXTRACTED 3 FACTORS.

FACTOR MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3
INST6	.76778	.30900	.00059
INST1	.70519	-.01650	-.49677
INST8	.68742	-.00839	.28975
INST2	.68144	-.05946	-.04572
INST10	.64592	-.13223	.20907
INST4	.63789	-.19916	-.48042
INST9	-.00430	.78003	.29012
INST5	.33443	.73654	-.18081
INST7	.32175	-.57206	.24622
INST3	.54648	-.04717	.61439

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
INST1	.74435	*	1	3.36181	33.6	33.6
INST2	.46998	*	2	1.63691	16.4	50.0
INST3	.67833	*	3	1.16231	11.6	61.6
INST4	.67738	*				
INST5	.68702	*				
INST6	.68496	*				
INST7	.49139	*				
INST8	.55657	*				
INST9	.69263	*				
INST10	.47841	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0 VARIMAX CONVERGED IN 5 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3
INST3	.82186	-.04939	.02093
INST8	.68876	.27684	.07254
INST10	.61368	.31413	-.05595
INST1	.14793	.84791	.05935
INST4	.12798	.80262	-.12962
INST6	.51412	.51488	.39438
INST2	.45280	.51442	.01808
INST9	.13346	-.26641	.77707
INST5	.04390	.30831	.76814
INST7	.44991	.09304	-.52945

FACTOR TRANSFORMATION MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3
FACTOR 1	.70415	.70087	.11382
FACTOR 2	-.08713	-.07380	.99346

HACKMAN AND OLDHAM'S [140] INTERNAL WORK MOTIVATION SCALE (INTWM)

A factor analysis of the scale was undertaken and the hypothesised factor structure of the scale was nearly supported. 2 Factors were extracted from the six items forming the scale. Factor 1 was formed by items 1, 2, 4, 5 and 6, and accounted for 50.7% of the total variance with eigen value of 3.04. Factor 2 was formed by item 3 only and accounted for 17.9% of the total variance with 1.07. All the items are pure as they load on the respective factors. No factor analysis was reported in the literature using the scale. However, there is an extensive documentary evidence on good reliability across a wide range of samples reported by Cook et al [86]. Reliability coefficients of 0.70 (pretest data) and 0.80 (main data) were obtained in this study.

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
INTWM1	1.00000	*	1	3.04488	50.7	50.7
INTWM2	1.00000	*	2	1.07698	17.9	68.7
INTWM3	1.00000	*	3	.63216	10.5	79.2
INTWM4	1.00000	*	4	.56103	9.4	88.6
INTWM5	1.00000	*	5	.44304	7.4	96.0
INTWM6	1.00000	*	6	.24191	4.0	100.0

0 PC EXTRACTED 2 FACTORS.

FACTOR MATRIX:

	FACTOR 1	FACTOR 2
INTWM2	.83474	-.28389
INTWM5	.80622	.10243
INTWM1	.79678	-.32615
INTWM4	.71896	.17006
INTWM6	.70624	.13162
INTWM3	.21805	.91284

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
INTWM1	.74124	*	1	3.04488	50.7	50.7
INTWM2	.77739	*	2	1.07698	17.9	68.7
INTWM3	.88082	*				
INTWM4	.54582	*				
INTWM5	.66049	*				
INTWM6	.51611	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0 VARIMAX CONVERGED IN 3 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2
INTWM2	.87261	-.12624
INTWM1	.84303	-.17474
INTWM5	.77384	.24833
INTWM4	.67566	.29884
INTWM6	.67020	.25872
INTWM3	.04721	.93733

FACTOR TRANSFORMATION MATRIX:

	FACTOR 1	FACTOR 2
FACTOR 1	.98309	.18311
FACTOR 2	-.18311	.98309

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1	FACTOR 2
INTWM1	.31271	-.24980
INTWM2	.31770	-.20874
INTWM3	-.08480	.84637
INTWM4	.20321	.19847
INTWM5	.24207	.14198
INTWM6	.20564	.16262

CAMMANN ET AL [62] WORK-PLACE-SUPERVISION SCALES

Based on prior exploratory research on the factor structure of these scales, a factor analysis was undertaken on each of the scales as follows:

1. Supervision - Control of Work (SUPCOW): The five items forming this scale were factor analysed and the analysis classified the items into orthogonal factor. A single factor structure was finally extracted accounting for 71.4% of the total variance and with eigen value of 3.57.

2. Supervision - Goal Setting (SUPGOS): The three items forming this scale were factor analysed and the analysis classified the items into orthogonal factor. A single factor structure was similarly extracted accounting for 75.5% of the total variance with eigen value of 2.26.

3. Supervision - Problem Solving (SUPROS): The two items forming this scale were factor analysed and a single factor was orthogonally extracted accounting for 86.5% of the total variance with eigen value of 1.73.

4. Supervision - Subordinate Relations (SSUBOR): The seven items forming this scale were factor analysed and the analysis classified the items into orthogonal factor. A single factor structure was finally extracted accounting for 48.5% of the total variance with eigen value of 3.39.

5. Supervision - Participation (SUPART): The two items forming this scale were factor analysed and a single factor was orthongonally extracted accounting for 82.5% of the total variance with eigen value of 1.65.

The factor structures and item loadings of the above five supervision scales presented in this study were similar to those reported by Cammann et al [62] as shown in Table D.3.

```
EXTRACTION  1  FOR ANALYSIS  1, PRINCIPAL-COMPONENTS ANALYSIS (PC)


INITIAL STATISTICS:

VARIABLE     COMMUNALITY  *  FACTOR   EIGENVALUE   PCT OF VAR   CUM PCT
                          *
SUFCOW1        1.00000    *    1       3.57129       71.4         71.4
SUFCOW2        1.00000    *    2        .61645       12.3         83.8
SUFCOW3        1.00000    *    3        .40450        8.1         91.8
SUFCOW4        1.00000    *    4        .23582        4.7         96.6
SUFCOW5        1.00000    *    5        .17193        3.4        100.0
0   PC EXTRACTED   1 FACTORS.

FACTOR MATRIX:

              FACTOR  1

SUFCOW2        .89412
SUFCOW4        .88440
SUFCOW3        .85450
SUFCOW1        .81780
SUFCOW5        .76858


FINAL STATISTICS:

VARIABLE     COMMUNALITY  *  FACTOR   EIGENVALUE   PCT OF VAR   CUM PCT
                          *
SUFCOW1         .66880    *    1       3.57129       71.4         71.4
SUFCOW2         .79945    *
SUFCOW3         .73017    *
SUFCOW4         .78216    *
SUFCOW5         .59071    *


VARIMAX  ROTATION  1  FOR EXTRACTION  1  IN ANALYSIS  1 - KAISER NORMALIZATION.

0)WARNING 11310
 )Only one factor was extracted.  The solution cannot be rotated.


FACTOR SCORE COEFFICIENT MATRIX:

              FACTOR  1

SUFCOW1        .22899
SUFCOW2        .25036
SUFCOW3        .23927
SUFCOW4        .24764
SUFCOW5        .21521


COVARIANCE MATRIX FOR ESTIMATED REGRESSION FACTOR SCORES:

              FACTOR  1

FACTOR  1      1.00000

-  1 PC  EXACT  FACTOR SCORES WILL BE SAVED WITH ROOTNAME: FCF19
-FOLLOWING FACTOR SCORES WILL BE ADDED TO THE ACTIVE FILE:

   NAME        LABEL

FCF191       REGR FACTOR SCORE   1 FOR ANALYSIS   1
-
```

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SUFGOS1	1.00000	*	1	2.26427	75.5	75.5
SUFGOS2	1.00000	*	2	.51266	17.1	92.6
SUFGOS3	1.00000	*	3	.22308	7.4	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
SUFGOS2	.90558
SUFGOS1	.90228
SUFGOS3	.79377

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SUFGOS1	.81411	*	1	2.26427	75.5	75.5
SUFGOS2	.82008	*				
SUFGOS3	.63007	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0)WARNING 11310
)Only one factor was extracted. The solution cannot be rotated.

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1
SUFGOS1	.39848
SUFGOS2	.39994
SUFGOS3	.35056

COVARIANCE MATRIX FOR ESTIMATED REGRESSION FACTOR SCORES:

	FACTOR 1
FACTOR 1	1.00000

- 1 PC EXACT FACTOR SCORES WILL BE SAVED WITH ROOTNAME: FCF20
-FOLLOWING FACTOR SCORES WILL BE ADDED TO THE ACTIVE FILE:

NAME	LABEL
FCF201	REGR FACTOR SCORE 1 FOR ANALYSIS 1

-

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SUFROS1	1.00000	*	1	1.72966	86.5	86.5
SUFROS2	1.00000	*	2	.27034	13.5	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
SUFROS2	.92996
SUFROS1	.92996

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SUFROS1	.86483	*	1	1.72966	86.5	86.5
SUFROS2	.86483	*				

REPRODUCED CORRELATION MATRIX:

	SUFROS1	SUFROS2
SUFROS1	.86483*	-.13517
SUFROS2	.86483	.86483*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 1 (100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0)WARNING 11310
)Only one factor was extracted. The solution cannot be rotated.

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1
SUFROS1	.53766
SUFROS2	.53766

COVARIANCE MATRIX FOR ESTIMATED REGRESSION FACTOR SCORES:

	FACTOR 1
FACTOR 1	1.00000

- 1 PC EXACT FACTOR SCORES WILL BE SAVED WITH ROOTNAME: FCF21
-FOLLOWING FACTOR SCORES WILL BE ADDED TO THE ACTIVE FILE:

NAME	LABEL
FCF211	REGR FACTOR SCORE 1 FOR ANALYSIS 1

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SSUBOR1	1.00000	*	1	3.39369	48.5	48.5
SSUBOR2	1.00000	*	2	.93057	13.3	61.8
SSUBOR3	1.00000	*	3	.82629	11.8	73.6
SSUBOR4	1.00000	*	4	.64407	9.2	82.8
SSUBOR5	1.00000	*	5	.59400	8.5	91.3
SSUBOR6	1.00000	*	6	.34161	4.9	96.1
SSUBOR7	1.00000	*	7	.26978	3.9	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
SSUBOR6	.84110
SSUBOR5	.75599
SSUBOR4	.75321
SSUBOR3	.73897
SSUBOR1	.60793
SSUBOR7	.58082
SSUBOR2	.54259

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SSUBOR1	.36958	*	1	3.39369	48.5	48.5
SSUBOR2	.29441	*				
SSUBOR3	.54607	*				
SSUBOR4	.56732	*				
SSUBOR5	.57152	*				
SSUBOR6	.70744	*				
SSUBOR7	.33735	*				

REPRODUCED CORRELATION MATRIX:

	SSUBOR1	SSUBOR2	SSUBOR3	SSUBOR4	SSUBOR5	SSUBOR6
SSUBOR1	.36958*	-.13938	.00654	-.15336	-.18064	-.01257
SSUBOR2	.32986	.29441*	-.02869	-.03489	-.07743	-.09111
SSUBOR3	.44924	.40096	.54607*	.01377	-.20384	-.15870
SSUBOR4	.45790	.40868	.55659	.56732*	-.06009	-.10940
SSUBOR5	.45959	.41019	.55865	.56942	.57152*	.04560
SSUBOR6	.51133	.45637	.62154	.63352	.63586	.70744*
SSUBOR7	.35310	.31515	.42920	.43747	.43909	.48852

OTHE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 13 (61.0%) RESIDUALS (ABOVE DIAGONAL) THAT ARE) 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

O)WARNING 11310
)Only one factor was extracted. The solution cannot be rotated.

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1
SSUBOR1	.17914
SSUBOR2	.15988
SSUBOR3	.21775
SSUBOR4	.22194
SSUBOR5	.22276
SSUBOR6	.24784
SSUBOR7	.17115

EXTRACTION 1 FOR ANALYSIS 1. PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SUFART1	1.00000	*	1	1.65029	82.5	82.5
SUFART2	1.00000	*	2	.34971	17.5	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
SUFART2	.90838
SUFART1	.90838

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SUFART1	.82515	*	1	1.65029	82.5	82.5
SUFART2	.82515	*				

REPRODUCED CORRELATION MATRIX:

	SUFART1	SUFART2
SUFART1	.82515*	-.17485
SUFART2	.82515	.82515*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 1 (100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION

0>WARNING 11310
>Only one factor was extracted. The solution cannot be rotated.

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1
SUFART1	.55043
SUFART2	.55043

Table D.3 Factor Loadings for Work-Place-Supervision Items (Cammann et al [62])

Scale/Item		Factor 1
Control of Work		
Items	1	.70
	2	.65
	3	.71
	4	.68
	5	.66
Goal Setting		
Items	1	.52
	2	.61
	3	.52
Problem Solving		
Items	1	.55
	2	.59
Subordinate Relations		
Items	1	.50
	2	.57
	3	.52
	4	.57
	5	.56
	6	.47
	7	.42
Participation		
Items	1	.52
	2	.41

SMITH'S [253] SUPERVISION SATISFACTION SCALE (SATISF)

A factor analysis of the scale was undertaken and two factors were extracted from the six items forming the scale. Factor 1 was formed by items 3, 4, 5 and 6, and accounted for 51.6% of the total variance with eigen value of 3.10. Factor 2 was formed by items 1 and 2 and accounted for 17.6% of the total variance with eigen value of 1.1.

Three of the items in the scale were however considered impure because they load on the two factors. These were items 2, 3 and 4.

The above scale was factor analysed by Smith [253] with other six scales of the Index of Organisational Reaction in which there was a total of 31 items in all and reported by Dunham et al [109]. Table D.4 shows factor loadings of the items forming the supervision satisfaction scale as reported by Dunham et al [109].

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SATISF1	1.00000	*	1	3.09468	51.6	51.6
SATISF2	1.00000	*	2	1.05453	17.6	69.2
SATISF3	1.00000	*	3	.73196	12.2	81.4
SATISF4	1.00000	*	4	.43062	7.2	88.5
SATISF5	1.00000	*	5	.36817	6.1	94.7
SATISF6	1.00000	*	6	.32003	5.3	100.0

0 PC EXTRACTED 2 FACTORS.

FACTOR MATRIX:

	FACTOR 1	FACTOR 2
SATISF3	.82960	-.02443
SATISF4	.80090	-.17620
SATISF2	.75736	.36372
SATISF6	.73099	-.43286
SATISF5	.58384	-.37558
SATISF1	.56232	.74978

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
SATISF1	.87837	*	1	3.09468	51.6	51.6
SATISF2	.70588	*	2	1.05453	17.6	69.2
SATISF3	.68883	*				
SATISF4	.67248	*				
SATISF5	.48194	*				
SATISF6	.72172	*				

REPRODUCED CORRELATION MATRIX:

	SATISF1	SATISF2	SATISF3	SATISF4	SATISF5	SATISF6
SATISF1	.87837*	-.13964	-.03815	.00426	.05817	.04329
SATISF2	.69859	.70588*	-.11567	-.10545	.07551	-.01081
SATISF3	.44819	.61942	.68883*	-.04622	-.12632	-.05242
SATISF4	.31825	.54248	.66873	.67248*	-.16735	-.06674
SATISF5	.04670	.30557	.49353	.53378	.48194*	-.21005
SATISF6	.08650	.39618	.61700	.66172	.58936	.72172*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 10 (66.0%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0 VARIMAX CONVERGED IN 3 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2
SATISF6	.84503	.08739
SATISF4	.74840	.33523
SATISF5	.69270	.04581
SATISF3	.68110	.47427
SATISF1	.00544	.93720
SATISF2	.39198	.74312

FACTOR TRANSFORMATION MATRIX:

	FACTOR 1	FACTOR 2
FACTOR 1	.80347	.59534

Table D.4 Factor Loadings for Supervision Satisfaction Scale (Dunham et al [109])

	Factor	
Item	1	2
1	.78	.18
2	-.78	-.18
3	-.67	-.16
4	.60	.11
5	.73	.09
6	-.75	-.21

HACKMAN AND OLDHAM'S [140] KNOWLEDGE OF RESULTS SCALE (KNOR) [QUALITY MEASURE INDEX]

A factor analysis of the scale was undertaken and the hypothesised factor structure of the scale was supported. A single factor was orthogonally extracted. The factor accounted for 63.1% of the total variance with eigen value of 2.53.

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
KNOR1	1.00000	*	1	2.52572	63.1	63.1
KNOR2	1.00000	*	2	.59674	14.9	78.1
KNOR3	1.00000	*	3	.45921	11.5	89.5
KNOR4	1.00000	*	4	.41833	10.5	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
KNOR2	.81438
KNOR1	.81394
KNOR3	.81319
KNOR4	.73398

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
KNOR1	.66250	*	1	2.52572	63.1	63.1
KNOR2	.66322	*				
KNOR3	.66128	*				
KNOR4	.53872	*				

REPRODUCED CORRELATION MATRIX:

	KNOR1	KNOR2	KNOR3	KNOR4
KNOR1	.66250*	-.12361	-.11221	-.11281
KNOR2	.66286	.66322*	-.08308	-.14456
KNOR3	.66189	.66225	.66128*	-.15866
KNOR4	.59741	.59774	.59686	.53872*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 6 (100%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION

0>WARNING 11310
>Only one factor was extracted. The solution cannot be rotated.

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1
KNOR1	.32236
KNOR2	.32244
KNOR3	.32197
KNOR4	.29060

KAHN ET AL'S [171] ROLE STRAIN SCALE (RAUTH)

A factor analysis of the scale was undertaken and four factors were extracted from the fifteen items forming the scale. Factor 1 was formed by items 1, 11, 12 and 13 and accounted for 44.1% of the total variance with eigen value of 6.62. Factor 2 was formed by items 7, 8 and 10 and accounted for 12.3% of the total variance with eigen value of 1.84. Factor 3 was formed by items 3, 4, 5, 6 and 9 and accounted for 7.5% of the total variance with eigen value of 1.13. Factor 4 was formed by items 2, 14 and 15, and accounted for 6.9% of the total variance with eigen value of 1.0. Perusal of the computer printouts, it will be noted that many of the items load on more than one factor. This is in agreement with hypothesised features of ambiguity and conflict in the role played by clerk of works in exercising his duties on site. It could be deduced that the role authority for the clerk of works on the achievement of quality of work on site was not explicit across respondents. Similar factor structure was reported by Mackinnon [200] and Khan et al [171] where the structure was consistent across the samples, with four principal components reflecting features of ambiguity and conflict. This is reported in Tables D.5 and D.6.

EXTRACTION 1 FOR ANALYSIS 1, PRINCIPAL-COMPONENTS ANALYSIS (PC)

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
RAUTH1	1.00000	*	1	6.62184	44.1	44.1
RAUTH2	1.00000	*	2	1.84296	12.3	56.4
RAUTH3	1.00000	*	3	1.12510	7.5	63.9
RAUTH4	1.00000	*	4	1.02957	6.9	70.8
RAUTH5	1.00000	*	5	.79154	5.3	76.1
RAUTH6	1.00000	*	6	.64459	4.3	80.4
RAUTH7	1.00000	*	7	.60093	4.0	84.4
RAUTH8	1.00000	*	8	.46834	3.1	87.5
RAUTH9	1.00000	*	9	.38668	2.6	90.1
RAUTH10	1.00000	*	10	.35249	2.3	92.4
RAUTH11	1.00000	*	11	.30233	2.0	94.4
RAUTH12	1.00000	*	12	.26112	1.7	96.2
RAUTH13	1.00000	*	13	.22010	1.5	97.7
RAUTH14	1.00000	*	14	.18337	1.2	98.9
RAUTH15	1.00000	*	15	.16904	1.1	100.0

0 PC EXTRACTED 4 FACTORS.

FACTOR MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
RAUTH5	.78266	.20332	-.33723	.15758
RAUTH13	.75998	-.26817	-.01550	-.11397
RAUTH3	.74433	.13923	-.31908	.13846
RAUTH6	.72800	.34069	.00798	.23103
RAUTH14	.71539	-.32077	.07380	.18131
RAUTH12	.68284	-.24651	-.07801	-.51397
RAUTH7	.67973	.39162	.17446	-.16722
RAUTH1	.67524	-.45345	.04237	-.11114
RAUTH2	.67402	-.37621	.06615	.31294
RAUTH10	.67083	.39879	.28375	-.26089
RAUTH11	.65383	-.40411	.14091	-.21227
RAUTH9	.55193	.42823	-.05916	.39955
RAUTH15	.50638	-.28311	.50170	.36121
RAUTH8	.54831	.58336	.26790	-.26323
RAUTH4	.50811	-.06255	-.65862	-.10672

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0 VARIMAX CONVERGED IN 15 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
RAUTH12	.83051	.28295	.16569	.00562
RAUTH11	.70322	.16535	.06853	.35939
RAUTH1	.69270	.06952	.17765	.39926
RAUTH13	.63936	.21612	.30663	.33645
RAUTH8	.09291	.86946	.13186	-.00485
RAUTH10	.26341	.80790	.14284	.12302
RAUTH7	.22725	.73276	.26037	.13202
RAUTH5	.24887	.33692	.76405	.18230
RAUTH3	.27462	.28682	.70853	.18629
RAUTH4	.44308	-.04526	.69072	-.17832
RAUTH9	-.17963	.42848	.58431	.30637
RAUTH6	.06119	.53295	.54463	.33924
RAUTH15	.17342	.16466	-.02663	.81293
RAUTH2	.39111	.00894	.33768	.65656
RAUTH14	.45969	.10973	.31730	.57354

FACTOR TRANSFORMATION MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FACTOR 1	.54557	.49470	.52744	.42360
FACTOR 2	-.57780	.69532	.23317	-.35820

Table D.5 Varimax-Rotated Factor Matrix for Role Strain Items (Mackinnon [200])

Item	Factor 1	Factor 2	Factor 3	Factor 4
1	.10	-.13	.21	.51
2	.22	.07	.51	.48
3	.19	.21	-.13	.80
4	-.12	.61	.51	.25
5	.48	.25	.54	.17
6	.27	.04	.78	-.00
7	.59	.04	.22	.28
8	.60	.10	.18	.34
9	.30	.65	-.07	-.09
10	.73	.14	-.00	.10
11	.67	.24	.18	.04
12	.73	.10	.29	.07
13	.26	.56	.40	-.01
14	.44	.20	.06	.39
15	.12	.67	.04	.11

Table D.6 Varimax-Rotated Factor Matrix for Role Strain Items (Kahn et al [171])

Item	Factor 1	Factor 2	Factor 3	Factor 4
1	.32	.08	-.07	.71
2	.25	.11	.28	.63
3	-.05	.05	.16	.73
4	-.06	.73	.20	.21
5	.46	.38	.36	.26
6	.14	.17	.80	.07
7	.62	-.04	.31	.35
8	.16	.29	.10	.63
9	.22	.56	.14	.16
10	.75	.26	.07	.04
11	.55	.19	-.03	.49
12	.54	.21	.42	.29
13	.12	.71	.35	.20
14	.33	.43	-.13	.42
15	.30	.60	-.16	-.11

BERKOWITZ'S [23] ROLE CLARITY SCALE (RCLARIT)

A factor analysis of the scale was undertaken and the hypothesised factor structure of the scale was supported. A single factor was extracted, orthogonally. The factor accounted for 68.5% of the total variance with eigen value of 2.74. The result of the factor analysis is in agreement with the hypothesised scale structure outlined by Berkowitz [23]. This is reported in Table D.7.

Table D.7 Factor Loadings for Role Clarity Items (Berkowitz [23])

Items	Factor 1
1	.728
2	.821
3	.829
4	.711

INITIAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
RCLARIT1	1.00000	*	1	2.73991	68.5	68.5
RCLARIT2	1.00000	*	2	.58017	14.5	83.0
RCLARIT3	1.00000	*	3	.38473	9.6	92.6
RCLARIT4	1.00000	*	4	.29519	7.4	100.0

0 PC EXTRACTED 1 FACTORS.

FACTOR MATRIX:

	FACTOR 1
RCLARIT3	.87583
RCLARIT2	.82280
RCLARIT1	.81088
RCLARIT4	.79893

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
RCLARIT1	.65753	*	1	2.73991	68.5	68.5
RCLARIT2	.67700	*				
RCLARIT3	.76708	*				
RCLARIT4	.63830	*				

REPRODUCED CORRELATION MATRIX:

	RCLARIT1	RCLARIT2	RCLARIT3	RCLARIT4
RCLARIT1	.65753*	-.05188	-.10838	-.17535
RCLARIT2	.66719	.67700*	-.11689	-.15184
RCLARIT3	.71019	.72064	.76708*	-.02495
RCLARIT4	.64784	.65737	.69973	.63830*

0THE LOWER LEFT TRIANGLE CONTAINS THE REPRODUCED CORRELATION MATRIX; THE DIAGONAL, COMMUNALITIES; AND THE UPPER RIGHT TRIANGLE, RESIDUALS BETWEEN THE OBSERVED CORRELATIONS AND THE REPRODUCED CORRELATIONS.

THERE ARE 5 (83.0%) RESIDUALS (ABOVE DIAGONAL) THAT ARE > 0.05

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

0>WARNING 11310
>Only one factor was extracted. The solution cannot be rotated.

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1
RCLARIT1	.29595
RCLARIT2	.30030
RCLARIT3	.31966
RCLARIT4	.29159

APPENDIX 4

DESCRIPTION OF THE PROJECTS OBSERVED

PART 1: FIRST SURVEY CASE STUDIES

(SOURCE: NEDO [219])

Appendix 4 **Description of the projects observed** Part 1 First survey case studies

(Random selection of projects from public sector)

Project size	● Small	●● Medium	●●● Large

Quality level	★ Poor	★★ Average	★★★ Good

Project no.	Project size	Description	Quality level	Contracting method	C of W	Active client or project manager	Public or private client	Drawings on site	Site management	Quality control	Comments
1.	●●●	Records Office	★★	Traditional (sequential tendering)	C of W	–	Public	Lack of sufficiently detailed drawings.	Competent but insufficient in number for this large job	Very effective team of C of Ws filled in deficiencies in design and management.	C of Ws team pulled project through with reasonable results but could not fully compensate for both design and site management deficiencies
2.	●●	Equipment centre	★★★	Traditional	C of W	–	Public	Uncoordinated and lacking in detail	Competent site agent with good site team.	Site agent filled in for ineffective C of W and very poor architect.	Contractors' site team made up for shortcomings in architect and C of W Site agent developed a good rapport with architects' senior draughtsman which enabled the good site management team to cope with inadequate design detail
3.	●	Equipment centre	★	Traditional	C of W	–	Public	Many mistakes on drawings	Only a working foreman provided Ineffective	C of W was extremely capable but was unable to totally overcome deficiencies in site management	At one stage, the C of W felt he could only compensate for inadequate site management by becoming directly involved in site operations The client stopped this involvement for contractual reasons. Quality suffered because the client was weak in dealing with contractors
4.	●●●	Training camp	★	Traditional	C of W	User client on site.	Public	Very poorly detailed and uncoordinated drawings	Poor project information had demoralised site staff resulting in lack of commitment	Poor site work checked by C of W but without adequate authority to improve matters.	Very poor project information had been too much for the average competence of contractor and C of W No back-up by architect Because architect and contractor performed poorly, and C of W had no-one sympathetic in authority to report to, the poor overall outcome was virtually inevitable.
5.	●●●	Barracks	★	Develop and construct	C of W	–	Public	Late and incomplete drawings.	Good overall control by contractor team but poor day-to-day control.	By contractors' staff and C of Ws but latter without any authority to improve quality levels.	Although a large C of W team was provided, it had no 'teeth' to improve quality because of the contractual procedure used. Thus any improvements resulted mainly from 'friendly persuasion'.
6.(a)	●	A number of buildings including schools, library, hostel	★★★	Traditional	Visiting C of W	–	Public	Adequate with architects available to explain their design.	Generally good. Working foreman used to working with this client. Little forward planning.	By tradesmen and C of Ws Very effective	Architects often on site plus a very authoritative C of W (reporting directly to chief architect) ensured good quality work, even though no site managers provided by contractors
7.	●	School	★★★	Design and manage (by architect)	Visiting C of W	–	Public	Timely and complete as necessary with architect on site several times a week	Casual but reasonably efficient management by architect and foreman.	By foreman and architect. Very effective.	Architect, through foreman, had excellent control Experimental contractual procedure worked well – considerably helped by high commitment of architect and most site operatives

(a) Note Project 6 in fact encompasses 12 different projects involving three visiting C of Ws observed over a four week period

Appendix 4 **Description of the projects observed** Part 1 First survey case studies (cont) *(Random selection of projects from public sector)*

Project size	● Small	●● Medium	●●● Large

Quality level	★ Poor	★★ Average	★★★ Good

Project no.	Project size	Description	Quality level	Contracting method	C of W	Active client or project manager	Public or private client	Drawings on site	Site management	Quality control	Comments
8.	●	Hostel extension	★★★	Traditional	C of W	–	Public	Timely, complete and very accessible architect	Foreman in charge slow but conscientious – asked advice from C of W or architect in the event of any difficulties	By bricklayer foreman, C of W, and architect.	Small enough project to be successful using very informal procedures such as making ad-hoc design alterations on site as work proceeded.
9.	●●	Offices	★★	Traditional	C of W	–	Public	Adequate	Conscientious agent hindered by uncaring contractors' HQ	By C of W but hindered by ineffective architect.	No-one really in control Agent and C of W of average ability had limited success in controlling project mainly due to poor back-up from architect and contractors' HQ.
10.	●●	Equipment centre	★★★	Traditional	Visiting C of W	–	Public	Adequate	Competent agent controlled site well	By agent in consultation with C of W	Excellent job. Agent in control helped by C of W performing dual role of inspector and informal technical adviser (Note. C of W may be inadvertantly legally liable for defects.)
11.	●●	Equipment centre	★★	Traditional	Visiting C of W	–	Public	Incomplete and poorly detailed drawings.	Conscientious agent *tending to* be worn down by poor information.	Tradesmen demoralised by poor information. No authority given to C of W to control information flow.	This relatively small but complicated project demanded more attention than it received from the architect and C of W.
12.	●●	Housing	★	Traditional	Visiting C of W	–	Public	Adequate	Houses being finished off by subcontract gangs No overall management on site.	Low calibre tradesmen skimping work Limited effect by C of W	Reliance on subcontractors' own control of quality was inappropriate. A visiting C of W cannot be expected to have much impact on quality since defects are soon covered by following trades.
13	●●●	Office refurbishment	★★★	Traditional	C of W	–	Public	Drawings did not take account of poorly set out and constructed existing building	Competent agent with good site team having well defined roles Supported by very capable C of W	By trades foreman and C of W	An extremely capable C of W together with the contractors' site team were able to offset the deficiencies in drawings and design.
14.	●●●	Barracks refurbishment	★★★	Traditional	C of W	–	Public	During BRE visit most work involved demolition.	Conscientious agent but without full control over subcontractors.	By C of W	Capable C of W kept contractor alert to his responsibilities
15.	●●●	Offices	★★★	Traditional	C of W	Building services engineer represented client	Public	Timely and complete drawings NBS type spec	Competent agent with good site team.	By section agents and C of W	Tight contract time. Good design and excellent drawings Efficient construction team (including architect) where each individual was important and contributed to the coordinated effort to ensure very good results

Appendix 4 Description of the projects observed Part 2 Second survey case studie(s) *(Random selection of projects mainly from the private secto(r) encompassing a range of contractual procedures)*

Project size ● Small ●● Medium ●●● Large

Quality level ★ Poor ★★ Average ★★★ Good

Project no.	Project size	Description	Quality level	Contracting method	C of W	Active client or project manager	Public or private client	Drawings on site	Site management	Quality control	Comments
16.(b)	●●●	Crown court	★★★	Traditional	C of W	–	Public	Late and not always complete.	Effective agent with good site team. Careful layout of offices and canteen to encourage consultation	By section foreman in conjunction with C of W.	Large and effective site team together with drawings coordinators provided by contractor and architect offset problems arising from late drawings Agent encouraged a 'communicative' site
17.	●●	Warehouse and office	★	Traditional	C of W	–	Private	Late and incomplete	Contractor failed to coordinate subcontractors No control over concreting gangs.	C of W had no authority No one checked the work	Unrealistic time constraint. Late and incomplete drawings, a C of W who was ignored and an inexperienced site agent with no back-up from his HQ made it unlikely this project would proceed well. Neither agent nor C of W had adequate authority.
18.(b)	●●	Laboratories and offices	★★	Traditional	Building C of W Visiting M&E C of W	User client on site	Public	Late and impractical No coordination between engineers' drawings and architects' drawings NBS type spec.	Uncoordinated subcontractors, but agent engendered good will on site	Conscientious C of W Drawings diverted attention from mangement and checking of work	Average ability site staff (C of W and contractor) were worn down by late and impractical services drawings No on-site supervision provided by services designer or services contractor
19.(b)	●●	Offices	★	Traditional	Visiting C of W rarely visited site.	–	Private	Late	Agent had severe problems coping Subcontractors organised themselves as best they could.	Architect discussed brickwork with bricklayer foreman, otherwise no checking	During period of observation, no attempts by contractor or architect to remove unsuitable agent No-one appeared interested in the project and quality suffered accordingly
20.(b)	●●	Shops and offices	★★★	Traditional	–	Representative of both clients for project sat in on site meetings and examined work on site.	Private	Late and incomplete.	Effective and conscientious agent worked well, sometimes overridden by his HQ	Agent checked work and advised architect on suitable corrective precedures	A confident and competent agent dealt with all site management, organised the architect and attempted to get round inappropriate directions from his HQ A combination of active client and a confident, competent and committed agent produced good work in spite of deficiencies in the design and project information
21.	●●●	Offices	★★★	Traditional	Assistant architect full time on site	–	Public	Late but assistant architect full time on site was able to fill in missing information.	Agent dealt with long-term planning leaving section agent and foreman to deal with day-to-day matters	By architect on site and by trades foremen.	Site staff worked in well-understood site management structure No real problems involving project information True team effort produced good results

(b) Note Full case study included in Appendix 2

Appendix 4 **Description of the projects observed** Part 2 Second survey case studies (cont)

(Random selection of projects mainly from the private sector encompassing a range of contractual procedures)

Project size ● Small ●● Medium ●●● Large

Quality level ★ Poor ★★ Average ★★★ Good

Project no.	Project size	Description	Quality level	Contracting method	C of W	Active client or project manager	Public or private client	Drawings on site	Site management	Quality control	Comments
22.	●	Training centre	★★★	Traditional, but architect had no responsibility for progress.	C of W.	Client's surveyor checked progress and finances.	Public	Adequate	Soon to retire agent lacked commitment. No overall control.	By C of W.	Extremely competent C of W with good client back-up pulled this project through in spite of the uninterested architect and contractor's agent. Project small enough for this to be effective
23.(b)	●●●	Training centre	★★	Construction management	Junior architect on site	Client's representative regularly inspected work	Private	Late and incomplete NBS type spec.	Conscientious management bogged down in paperwork – unused to construction management.	Inexperienced architect on site only had limited effect.	Overall management good but contractor's day-to-day control poor. Very rushed design and installation of services caused many problems. Contractor and architect unfamiliar with contractual arrangement – much time spent learning how to make the system work well.
24.	●●●	Offices	★	Management contract	Visiting engineer	–	Private	Late drawings	Large but inexperienced site team were having difficulties controlling the low standard subcontractors.	No quality control. Management contractor's section agents had no power to improve quality. Engineer not often on site.	Subcontractors with little organisational ability coupled to ineffective management contractor's site staff led to very poor work. The generous size of the site team could not compensate for their inexperience.
25.	●●●	Department store	★★★	Management contract	Visiting engineer	Consultant project manager and client's in-house representatives regularly inspected site	Private	Good	Experienced site team generally controlled site well	By section foremen and client's representative.	Management contractor relied on selecting subcontractors with whom they had worked successfully before and providing on-site foremen well backed up by office staff
26.	●●●	Offices	★	Management contract	Visiting engineer	Consultant project manager advising client	Private	Good	Large but inexperienced site team were having difficulties controlling the various contractors	No quality control Management contractor's section agents had no power to improve quality. Engineer not often on site	Subcontractors with little organisational ability coupled to ineffective management contractor's site staff led to poor work. Consultant project manager aware of the situation but no action from client at the time of the BRE visit.

(b) Note Full case study included in Appendix 2

Appendix 4 **Description of the projects observed** Part 3 Third survey case studies

(Projects encompassing a range of contractual procedures and where the BRE initial contact (client, contractor, architect) felt the project was proceeding reasonably well)

Project size ● Small ●● Medium ●●● Large

Quality level ★ Poor ★★ Average ★★★ Good

Project no.	Project size	Description	Quality level	Contracting method	C of W	Active client or project manager	Public or private client	Drawings on site	Site management	Quality control	Comments
27.	●	Refurbish school and new extensions	★★	Traditional	–	Frequent discussions with head teacher.	Private	Poorly coordinated and incomplete	Agent reluctant to exercise any control.	By tradesmen – quite effective.	On this small simple project, conscientious workmen with limited supervision produced reasonable work.
28.(b)	●●	Offices and workshops	★★★	Traditional, negotiated	–	Close links with staff in completed phase 1.	Public	Reasonably complete and timely – well backed up verbally by architect.	Agent very firmly controlled site. Well organised and planned.	By agent, supported by contractor's foreman.	An authoritative and competent agent plus a lively site team, well supported by the architect produced conditions in which good quality was likely to be achieved.
29.	●●●	Offices with some shops	★★★	Management contract	On site archit-ect and C of W.	–	Private	Drawings late on site and uncoordinated	Generally good overall control but poor day-to-day control.	By trades foremen and contractor's supervisors.	In spite of a tight contract time, good selection of contractors by management contractor and good overall management was able to offset the poor design information and day-to-day management.
30.	●●	Major refurbishment of offices	★★★	Management contract	–	–	Private	Timely and complete.	Well-trained and successful site team transferred intact from previous project.	By managers liaising with foremen, supervisors, etc.	An experienced and well-trained site management team with more than usual authority, coupled with good information, produced good work.
31.	●	Hotel extension	★★	Traditional	–	–	Private	Only a few problems. Architects' office nearby.	Knowledgeable and authoritative agent ran site well.	By agent.	Site observed at very early stage. Concrete finish good
32.	●	Cottage hospital	★★	Traditional	C of W	–	Public	Details lacking or poorly worked out.	No real attempt by agent to control site.	By C of W who behaved very formally avoiding close involvement outside his inspection duties	A formal C of W unable to totally overcome poor drawings and largely ineffective site management.
33.	●●	Factory extension	★★★	Traditional	Visiting archi-tects' repre-senta-tives.	On-site client's representative.	Private	Timely and complete. NBS type spec.	Inexperienced agent did not control site well.	By architects' representative.	Reasonably successful outcome produced by architects' representative and client's representative in spite of inexperienced contractor's management.
34.	●●●	Offices	★★	Design and build	–	–	Private	Late drawings.	Effective agent with good site. team.	By site management team.	Agent had taken 'problem' project over and was working hard effecting remedial measures. Though a 'design and build' contract, it suffered from late drawings.

(b) Note Full case study included in Appendix 2.

Appendix 4 **Description of the projects observed** Part 3 Third survey case studies (cont)

(Projects encompassing a range of contractual procedures and where the BRE initial contact (client, contractor, architect) felt the project was proceeding reasonably well)

Project size	● Small	●● Medium	●●● Large

Quality level	★ Poor	★★ Average	★★★ Good

Project no.	Project size	Description	Quality level	Contracting method	C of W	Active client or project manager	Public or private client	Drawings on site	Site management	Quality control	Comments
35.	●●	Offices	★★	Traditional	C of W. Visiting junior architect.	–	Private	Late and poorly detailed due to rush to get project started.	Agent dealt with forward planning plus effective site team.	By section agents and contractor's supervisors.	Well-trained contractor's site team working well but unable to totally overcome poor design and drawings
36.	●●●	Airport terminal	★★★	Construction management plus some design involvement.	Client inspectors	Client in-house liaison team. Full design team on site.	Public	Reasonably timely and complete	Well-trained and very large number of managers on site	By contractor's inspectors and site management	Extremely proficient contractor's site team backed up well by consultant engineers. Good design, reasonable drawings and good site management produced good work.
37.	●●●	Offices	★★★	Design and build	C of W	*Developer and* funding institution strong presence on site.	Public/ private	Architect employed by contractor not committing sufficient resources to project.	Experienced site agent with *large* well-trained site team.	By site agent and section foremen primarily, with client's C of W in the background.	Extremely well coordinated and trained contractor's team coped well with deficiencies in their own design team and in dealings with the strong clients. The strong client presence almost certainly helped in ensuring the 'design and build' contractors gave of their best.
38.	●●	Offices	★★★	Design and build	–	Inquisitive overseas client.	Private	Very incomplete	Well-trained experienced agent.	By agent.	Experienced agent was able to overcome deficiencies in design and drawings production and satisfy client.

APPENDIX 5

ACKNOWLEDGEMENT FROM ORGANISATIONS AND INDIVIDUALS

NATIONAL COUNCIL FOR BUILDING RESEARCH STUDIES AND DOCUMENTATION
EIL INTERNATIONAL DU BATIMENT POUR LA RECHERCHE L'ETUDE ET LA DOCUMENTATION

CIB

al secretariat

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Mr. Habu Sani
Heriot-Watt University
Department of Building
Chambers Street
Edinburgh EH1 1HX
United Kingdom

562-7/-

Rotterdam, 10th April 1985

Dear Mr. Sani,

Thank you for your letter dated 29th March 1985. We are enclosing two documents prepared for the next Meeting of our Programme Committee in May 1985, both on quality assurance. These have the status of internal working documents so that we send them for your information only.

Nevertheless, we authorize you to quote from these (including the use of diagrams) under the usual condition that the source is acknowledged.

The establishment of a CIB Working Commission on Post Construction Liability and Insurance is currently under active consideration. You will want to note this for possible future participation. The CIB Information Bulletin will keep you informed as to progress.

Yours sincerely,

Prof. Dr. Gy. Sebestyén
Secretary General

Encl.: P.C. 32/393(85)
Appendix 1 to P.C. 32/393(85)

GS/DP

DEPARTMENT OF THE ENVIRONMENT

Building Research Establishment

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GTN 2532 Telex 923220

Mr Habu Sani
Heriot-Watt University
Department of Building
Chambers Street
EDINBURGH EH1 1HX

telephone extension: 7101

your reference: HS/CFH

our reference:

date: 12 April 1985

Dear Mr Sani

QUALITY ASSURANCE STUDY

You have identified, in your letter of 28 March, the most recent BRE publications on levels of quality, and their maintenance in construction. However, work has been continued and further publications will eventually emerge.

Mr Bentley's research study into the operation of quality control on site is due to end by the middle of this year. In the final stages of the work we have the assistance of a specially arranged EDC Committee, so that the final report is expected to combine our research work with considered opinions on its implications and implementation from the EDC Committee. No publication date is yet established, but I expect all the work will be completed in the current year.

The work by Harrison and Bonshor, into quality standards normally achieved on 'traditional' housing sites, has been extended to timber-framed housing and to rehabilitation of housing. Both studies are still in progress and it is unlikely that anything will be openly published before next year. The timber-frame results may be out first, but I imagine you will be more interested in the rehabilitation work, since so much of this is undertaken by Housing Associations.

In addition to these projects, we have also started to look at quality assurance in the industry. The only publication available so far is a Current Paper.* (As Current Papers are now charged for, I am sorry I cannot send you a copy; however, you probably already have one in your Library). A similar conformance study into ready - and site-mixed mortars and their constituent sands is shortly to be reported.

/Other BRE publications

* Current Paper No 4/83 'The Conformance of some common building products with British Standards'

Other BRE publications of direct relevance to quality control on housing sites are those of our Housing Defects Prevention Unit, which is under Mr Harrison's control. I think you should be familiar with their Defect Action Sheets.

Organisationally, all these items of work come within my own Building Process Division, but feel free to approach the individual authors for further details of their work, although - as I have indicated - there is little further they can give at this precise moment.

Yours sincerely

Ian Freeman

IAN FREEMAN
Head of Building Process Division

National Research Council Canada
Division of Building Research
Ottawa, Canada
K1A 0R6

Conseil national de recherches Canada
Division des recherches en bâtiment

File Référence 85-I-TIG-088
M43-3-92

1985-05-30

Mr. Habu Sani
Department of Building
Heriot-Watt University
Chambers Street
Edinburgh
EH1 1HX

Your Reference: HS/CFH

Dear Sir:

RE: Quality Assurance Study

Thank you for your letter of 1 May 1985.

Quality assurance is one area in the design-build process that we have not studied though our Building Performance Section, when analyzing building problems, have often come across instances of poor design and construction practices.

In Canada the responsibility for quality control rests with the General Contractor and the Designer, at least one blames the other when things go wrong.

Many factors contribute to poor quality from lack of proper details, to improper selection of materials, lack of experience and poor motivation on the jobsite. If I were asked, however, to identify the one critical area which more than any other influences performance I would have to name detailing. Details must not only satisfy the requirements of the system but they must also be designed so that they can be built. It is one area that we and others have stressed in the last seven or eight years and there appears to be an improvement in this regard.

I trust that these few comments will be useful.

Sincerely,

R.G. Turenne
Head, Technical Information Group

RGT:mrf

85-TIG-130

Canada

CIRIA **Construction Industry Research and Information Association**

Registered Office: 6 Storey's Gate Westminster London SW1P 3AU
Telephone: 01-222 8891 Telex: 24224 (please preface messages "2063")

RP 360/ARM/LL 3 June 1985

Habu Sani Esq
Department of Building
Heriot-Watt University
Chambers Street
EDINBURGH
EH1 1HX

Dear Mr Sani

RP 360: Quality Assurance in civil engineering

Thank you for sending me the copy of your letter dated 26 March, addressed to Mr Power. I am sorry you did not receive a reply. Progress to date can be summarised as follows:

Mr R D Power of Freeman Fox and Partners was seconded to CIRIA to carry out the project in October 1984 and finished that secondment on 1 May this year. He has prepared a first draft report (copy enclosed for information) which has been edited to produce a second draft. This second draft will be considered at a meeting of the Steering Group on 7 June. Subject to their approval, the draft will be prepared for publication. It is hoped publication will be during this year, but I cannot guarantee that, bearing in mind the further editorial effort necessary.

I trust that the above is sufficient information for the present, but please do not hesitate to contact me if further details are needed.

Yours sincerely

A. R. McAvoy

A R McAvoy
Research Manager
Civil Engineering Construction

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Mr Habu Sani
Dept of Building
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Chambers Street
Edinburgh EH1 1HX

Tel ext: 691
Your ref: HS/CFH
Our ref: A147/7/6
Date: 7.6.85

Dear Mr Sani

Regarding your letter of the 26 April, I would be very pleased for you to visit me here at BRE to discuss quality control on building sites.

My work of the last few years has been specifically on quality control but my colleague Keith Snook has recently become involved in quality assurance and together I feel we should be able to give you some useful information.

I should point out that our quality control research has not involved housing, only one-off projects, but the results have tied in well with other work on housing.

Perhaps the best way to arrange a meeting would be for you to telephone me to arrange a suitable date.

I enclose a copy of BRE Current Paper CP7/81 - Quality control on building sites and the accompanying Information Paper IP28/81.

Yours sincerely

Michael Bentley.

M J C Bentley

drv

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telephone extension: 691

your reference: HS/CFH

our reference: A147/7/6

date: 23 August 1985

Dear Mr Sani

I hope you found your visit here on the 13 August useful. I did say I would send you some more information on our research findings but in fact the notes I gave you on the 13th do cover very well most of the points that have emerged during the research.

I look foward to hearing from you again when you have progressed your programme of research.

Yours sincerely

Michael JC Bentley.

M J C Bentley
Bldg Process Division

PLANUNGSVERFAHREN IM BAUBETRIEB
RHEIN.-WESTF. TECHNISCHE HOCHSCHULE AACHEN
PROFESSOR DR.-ING. R. SEELING

Planungsverfahren im Baubetrieb der RWTH
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5100 AACHEN, den 29.08.1985

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S c o t l a n d

Quality assurance study

Dear Mr. Sani

You asked for informations and results of quality-research. I have no own paper in this field and therefor I send you a publication of my collegue Adolf Schub from Munich, presented a few months before your letter.

Another possibility for you is a question to Prof. Dipl. Bau-Ing. J. Schneider from the ETH in Zürich/Schwitzerland. He made a presentation about "Qualitätssicherung im Bauprozeß" on the 17. Jan. 85 in the University of Stuttgart.

I hope you will be succe sfull.

With kind regards

Yours sincerely

Reinhard Seeling

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PRIDE IN THE JOB
TECHNICAL DEPARTMENT
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Mr H Sani
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Chambers Street
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DHK/CS/57

6th December 1985

Dear Mr Sani

Re: Quality Assurance Study

Thank you for your letter dated the 27th November 1985.

As far as housing building is concerned we continually do the job you propose to research. We monitor claims made on NHBC and the experience of our inspectorate and look for cost effective ways of improving standards, designing out faults and through our Newsletters and publications advise builders of the precautions to take.

We have also introduced incentives through our Pride in the Job Scheme and we are currently investigating how both our own organisation and the organisation of the builders could be improved and geared to the attainment of quality. We have already carried out an experiment with 10 builders. We are working with consultants to extend the experiment to a further 30 builders with a view to introducing the whole of the house building industry to cost effective quality management including taking account of the recommendations of BS 5750.

From this letter you will see that the whole of NHBC organisation is set up to improve standards of the quality of house building. There is no publication which covers precisely what we do and how we go about our work. It may be of interest to you that BRE have also done a vast amount of work on the identification of the defects and what caused them. This is a huge subject which cannot be tackled by general research. Your enquiry is so general that we are not able to identify areas where we might be able to help. I believe you will need to carefully consider precisely what you intend to do and the objectives otherwise I suspect you will be swamped with the problems.

Yours sincerely

D H KETTLEWELL
DIRECTOR OF STANDARDS & RESEARCH

BP

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Mr H Sani
Department of Building
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Our ref BD4270

Your ref

Date 11 December 1985

Dear Mr Sani

QUALITY ASSURANCE AND PSA

In answer to your letter of 26 November I am enclosing a copy of our booklet "Selling Building Product for PSA Work". This explains PSA policy on buying and specifying building products and gives strong emphasis on our commitment to Quality Assurance.

I am also enclosing a copy of an article by Anthony Hill who is the head of the Quality Assurance Unit (formerly known as Product Quality Unit). This was published in BSI News in August 1985 and explains the background to PSA's involvement in Quality Assurance.

I wish you well in your research.

Yours sincerely

Jerry McCarthy

T A McCARTHY
Quality Assurance Unit

Registered Office: 58 Portland Place, London W1N 4BU

National House-Building Council

NHBC

PRIDE IN THE JOB

TECHNICAL DEPARTMENT
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Mr H Sani
Heriot-Watt University
Chambers Street
Edinburgh
EH1 1HX

DHK/CS/57

16th April 1986

Dear Mr Sani

Re: Quality Assurance Study

Thank you for your letter dated the 4th April 1986.

Your proposals sound interesting and if the investigation can be quantified they might be very helpful.

I wonder whether it would be possible to monitor in a detailed way part of the construction to establish a daily record of problems encountered and mistakes made and the time they took to be corrected with a view to tracing back problems and mistakes to their prime source. I asked the question because I suspect that much of what we place blame on workmanship may have causes elsewhere. We could not reasonably blame workmanship if we did not give the man doing the job the right tools and the right information.

I would not make too many assumptions on the adequacy of the documentation.

I wish you good fortune in your project.

Yours sincerely

D H KETTLEWELL
DIRECTOR OF STANDARDS & RESEARCH

CIRIA Construction Industry Research and Information Association

Registered Office: 6 Storey's Gate Westminster London SW1P 3AU
Telephone: 01-222 8891 Telex: 24224 (please preface messages "2063")

PROP 1029/ARM/LJO

27 March 1987

Mr H Sani
Department of Building
Heriot-Watt University
Chambers Street
Edinburgh
EH1 1HX

Dear Mr Sani

PROP 1029 : Quality Assurance - Phase 2

I refer to your enquiry about our activities regarding Quality Assurance.

CIRIA is currently involved with the following:

1. A client's guide on QA for construction (PROP 1058)

2. Setting up a QA forum for the construction industry (PROP 1080)

3. Organising QA appreciation seminars

Papers covering the two proposals are attached together with some other background reports on various QA activities.

The joint AC1-3 Working Party will not be meeting again in its present form. The QA forum will in effect be taking over this role. Further information on the QA appreciation seminars will be sent to you in the near future, the first one will be held in Birmingham on 25 June 1987. Attendance at the QA Forum will be by invitation only.

Yours sincerely

A.R. McAvoy

A R McAvoy
Research Manager

Lloyd's Register
Quality Assurance Ltd.

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Heriot-Watt University
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Our Ref LRQA/870477

Your Ref HS/AJM

Date 11th May 1987

ATTN: MR SANI

Dear Mr Sani,

In response to your letter of the 28th April 1987, I have enclosed a selection of brochures which indicate some areas of activity in QA assessments. We have been involved in Project Management type organizations and in this respect I have enclosed our Quality Supplements which are used for these assessments. In all cases, our approvals are to the appropriate part of BS 5750, the supplements are simply documents which amplify some of the clauses in the standard.

In a recent conference for BCIRA, I presented a paper on typical assessment problems when viewed against the requirements of the standard BS 5750 and a copy of this could be made available.

Yours sincerely,

R. Turner

R. TURNER
GENERAL MANAGER

encl:

rt/njr

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Our Ref : G/B91/JRB/sjl
Date : 13th January 1987

Mr Harbu Sani
Department of Building
Heriot-Watt University
Chamber Street
Edinburgh EH1 1HX

Dear Harbu Sani

QUALITY MANAGEMENT RESEARCH

I enjoyed our discussion at the last BQT meeting and I am sure your work with Housing Associations will bear fruit for the good of the industry and its customers.

Enclosed is a copy of the results of an on-line international literature search and a copy of the booklet on Project Quality Management. In return perhaps you would provide me or the BQT with a copy of your dissertation.

My company is active in quality management and we have been impressed by the commitment shown by shareholders of client companies as they invest in the management approach and training necessary for cost-effectively meeting customer requirements.

Not least in the vanguard of change are the purchasing agencies who realise that they can benefit by helping their suppliers of products and services to improve their own quality management performance beyond that required by BS 5750.

This will lead to the development of procurement policy and strategy to improve quality performance in many fields including construction. Should any of 'your' Housing Associations ask for advice in this area please let me know.

Good luck with your research.

Yours sincerely

John R Broomfield
HARRY STANGER LTD

Department of Construction Management
University of Reading

TC/mr

1 November 1985

Mr Habu Sani
Dept of Building
Heriot-Watt University
Chambers Street
Edinburgh EH1 1HX

Dear Mr Sani

QUALITY ASSURANCE STUDY

Thank you for your letter dated 9 August 1985 and my apologies for not replying sooner.

I am coming to Heriot-Watt on Friday 22 November to see John Kelly. If you arrange with him for us to meet some time during the morning I have quite a lot of information about the current development of quality management in my own and other's work.

Yours sincerely

Tim Cornick

Tim Cornick

11 15

Department of Construction Management
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Department of Construction Management

University of Reading

Professor W D Biggs
Head of Department

Professor V Torrance
Department of Building
Heriot-Watt University
Chambers Street
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3 December 1985

Dear Victor

BUILDING QUALITY TRUST

It is our intention to promote building quality through fundamental research and education in design and construction management. Our research aims will be to study how 'quality' matters can be defined, measured and enforced in the building design and construction process. Our education aims will be to ensure that 'quality' becomes an integral part of building project management at undergraduate, postgraduate and continuing professional development levels. Our philosophy towards 'building quality' is based on the principles of BS 5750 being applied throughout the building process and the need to form technology knowledge bases for modern building construction. Both aspects are interdependent and should be accommodated in future computer-based systems for construction management.

We consider it necessary that there should be 'all-industry' support for and understanding of 'building quality' matters - from client to tradesman - in the building process and the formation of a Trust provides such a focal point for research and education initiatives. The support of major institutions involved in the building process should ensure 'all-industry' agreement on needs and implementation methods to promote building quality.

Tim Cornick has spoken with Habu Sani about his quality study. I think both would benefit if Habu represented you on the Trust for the remainder of his period of study.

Yours sincerely

Bill

W D Biggs
Professor of Technology
and Head of Department

H. Sani,
Please discuss
BT
12/12.

University of Reading
Whiteknights
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Department of Construction Management

University of Reading

TC/pas

12 September 1986

Mr H Sani
Heriot-Watt University
Department of Building
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Dear Habo

Building Quality Trust

We have now recieved an award from the Science and Engineering Council to carry out a two year research project to develop a 'quality management model for building projects'. The initial stage of the study will entail a general search of what is currently occuring in the construction industry and related professions with regard to building quality matters and we intend to present and discuss our findings at the next meeting of the Trust to be held on the MONDAY 24 NOVEMBER 1986.

It is then our intention to develop a theoretical model for quality management for the briefing/designing stage of the building process by studying a small sample of commercial client organizations and architectural practices and test and refine the model through its controlled introduction to live projects. The final outcome of the research project will be in the form of guidance documentation that can be commonly accepted and to this end we will use the Building Quality Trust Meetings - with their 'all industry' representation - as a controlling influence throughout the project.

I shall be pleased if you will let me know if you or another representative - can attend the next meeting as soon as possible so that some preparatory documentation can be sent before the meeting.

Attendance at all the Trust meetings during the research will be free, a buffet lunch will be provided and they should last from about 10am - 4pm each time.

Yours sincerely

Tim Cornick

Tim Cornick
Research Project Manager

Department of Construction Management
University of Reading
Whiteknights
P O Box 219

DEPARTMENT OF THE ENVIRONMENT

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Mr Habu Sani
Heriot-Watt University
Chambers Street
EDINBURGH EH1 1HX

telephone extension: 691

your reference: HS/SJR

our reference: A147/7/6

date: 4 November 1985

Dear Mr Habu Sani

Thank you for your letter and copies of your questionnaires.

One of the problems here is that respondents will tend to answer the questions regarding what would happen in a perfect world, rather than what actually takes place. As it stands, your analysis of results will have to be very careful and circumspect. I know it is difficult but it is better if you can ask questions about a specific project.

SECTION 1

HOUSING ASSOCIATIONS QUESTIONNAIRE

1.1 Q4 - a) I do not think you can say "well documented" - it means so many things to so many people. You could ask to how many pages it runs.

Also, many clients effectively brief their consultants via a series of letters to them - not a particularly good way but it often happens.

Q11 - Always, frequently, occasionally, - rather vague terms! Could you be more specific?

Q12 - Isn't everyone going to answer 5,5,5,5,5,5.

Q16 - I am afraid I cannot see sensible answers coming from this question. Surely no-one is going to admit to laying down unclear lines of communication.

You could rephrase the question as follows:-

How do you ensure that the various team members are conscious of quality when producing information or in the course of their work?

a) By prescribing their individual and collective responsibilities at the outset.

b) By establishing a communication system for the team.

c) By allowing normal working practices form the teams working environment.

NOTE:- I am not sure what your 16(c) means - coordination and

2 CLERK OF WORKS QUESTIONS

Perhaps you should make it clear that Clerks of Works should answer these questions.

Q7 - You could add (e) "your other commitments."

INTENANCE

3 Q9 - I would suggest that many inspections made are not really structured at all, but I admit it is difficult to phrase questions formally to determine how structured inspections are. Your question 9 seems to imply that they know exactly what they are doing!

Again a very careful and circumspect analysis will be necessary here.

ECTION 2

1 Many of these questions are effectively asking "How often do you do your job properly?"

What sorts of answers are you expecting!

If you rephrased the questions on the following lines - "How often does the Client require an appraisal and recommendation...." then the answers might be more truthful.

Q3 - Could be rephrased "How often are you allowed sufficient time ..."

2 No specific comments

3 I like the layout of these questions.

4 Q3 Who is going to admit to not taking care over important details?

ECTION 3

1 No comments

2 No comments

3 Q10 - I do not really understand the language used.

Q11 - You could just say "Poor storage, handling and protection of components on site are major causes of loss of performance in those components."

Q19 - Does this mean site management must avoid their firm going bankrupt

4 I liked these sorts of questions except Q17 - "condemn (poor) ~~good~~ workmanship"!!

Generally, I hope you get a good number of respondents and that you have fun sorting out the answers and trying to make sense of them!

gards

Michael J C Bentley.

J C Bentley

Oscar Faber Consulting Engineers
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HS/ACC ITC.0133/053

Mr H Sani
Heriot-Watt University
Department of Building
Chambers Street
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7 November 1986

Dear Mr Sani

I refer to your letter dated 30 September 1986 and apologise for the delay in replying.

I have read through your hypothesis together with the accompanying questionnaires and, whilst seeing your objectives as having real value, I doubt whether they can be implemented in practice.

The questionnaires are very extensive and even assuming that you were able to get these properly completed; which I doubt that you ever would, who would objectively analyse the answers?

For the analyses to be objective there will have to be a model set of answers. How will these be prepared and against what criteria?

I am sure that you will have given these points some consideration since the format of your questionnaires appears to make provision for an answer grading points system.

Your questionnaire in respect of the Client's representative reads to myself as if you are seeking to question the skills and experience of a person who may have already been appointed. Is this not being rather presumptious? Have you thought about the course of action which would have to be taken if that person's response was not in line with the expectations?

The questionnaires for the Consulting Architect and the Contractor's Site Agent/Manager are very searching. I would question whether you would ever get these fully answered except possibly in an unusually competitive situation.

/Contd..

Your objectives are commendable but as far as work in the UK is concerned, I doubt whether they could be fulfilled.

I think the more positive approach would be for you to go forward with a philosophy which puts the onus on to those concerned with the work to demonstrate their use of quality systems which meet the standards appropriate to the country in which the work is to be undertaken.

I do apologise for the somewhat pessimistic response but I have no wish to give you any other opinion but an honestly realistic one.

If you would like to respond with your own comments, I assure you that they will be given my considered attention. Meantime, I am now returning your questionnaires to keep the duplicating costs down.

Best wishes to you.

Yours sincerely
OSCAR FABER CONSULTING ENGINEERS

Ian Clark.

I T Clark

ITC/JB